MANUAL

OF THE

DISEASES OF THE EYE

FOR STUDENTS AND GENERAL PRACTITIONERS

WITH 243 ORIGINAL ILLUSTRATIONS
INCLUDING 12 COLORED FIGURES

BY

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PREFACE.

In the following pages the author has endeavored to present a concise, practical, and systematic Manual of the Diseases of the Eye, intended for the student and the general practitioner of medicine. The great difficulty in preparing a book of this sort is to say enough but not too much. With this idea in view, the author has made the volume sufficiently comprehensive, up to date, and yet of such limited size that it can, if desired, be carried in the pocket.

This restriction in size has been accomplished by omitting excessive detail, extensive discussion, and lengthy accounts of theories and rare conditions. The author has endeavored to give the fundamental facts of ophthalmology and to cover all that is essential in this branch of medicine, always keeping in mind that the book has been written for students and general practitioners. Space therefore has been allotted as the necessities of such readers require, estimated by an extended experience in teaching. Thus, rare conditions have merely been mentioned; uncommon affections, of interest chiefly to the specialist, have been dismissed with a few lines; and common diseases, which the general practitioner is most frequently called upon to treat, have been described with comparative fulness.

The book is not recommended as a substitute for the larger works, but as a means of supplying a foundation to

which further knowledge may be added by reference to more extensive and comprehensive text-books.

The illustrations, excepting those showing instruments, are original, and have been inserted wherever it seemed that they would be of value in elucidating the text. Those in colors represent the most common ophthalmoscopic conditions, a knowledge of which is desirable in the treatment of general and nervous diseases as well as in ocular diagnosis.

The index has been made rather fuller than is customary in books of this size, to facilitate reference, and also to serve as a dictionary of terms used in ophthalmology. A list of abbreviations and signs commonly employed is given on page 281.

The author desires to express his thanks to his friend, Dr. Ward A. Holden, for his kindness in reading and criticising the manuscript and for a number of valuable suggestions.

CHARLES H. MAY, M.D.

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INTRODUCTION.

THOROUGH examination of the eye requires the adoption of a certain routine. The history of the patient's complaint will lead the trained observer to concentrate his attention upon the affected part of the eye; but until proficiency is gained through experience it is not safe to depart from a systematic plan of examination.

The eye, being intimately associated with the rest of the body, must not be regarded as an isolated organ. Hence a knowledge of the condition of the system is often valuable in the diagnosis and successful treatment of ocular disease. The parts immediately surrounding the eye must also receive careful attention.

The *systematic examination* of the eye may be divided into

(1) *Objective,*

(2) *Subjective or functional.*

The *objective examination* may be subdivided into

(a) Examination of the appendages and the anterior portions of the eyeball by means of *inspection and palpation;* this part of the examination is usually conducted in *daylight.*

(b) Examination of the cornea and of the interior of the eyeball in the *dark room,* with *artificial light,* by means of *oblique illumination* and the *ophthalmoscope.*

DISEASES OF THE EYE.

CHAPTER I.

EXTERNAL EXAMINATION OF THE EYE BY MEANS OF INSPECTION AND PALPATION.

INSPECTION.

THOSE parts of the eye which will admit of examination by daylight are best illuminated by seating the patient so that he faces a window. Taking a *general survey* of the eyes, we notice certain *prominent symptoms*, such as congestion, discharge, lachrymation, photophobia, etc.

Proceeding from the superficial to the deeper parts, we commence with the *lids*, noticing their thickness, color, and position; the condition of their margins, whether swollen, crusted, or ulcerated; the power of opening and closing; the size of the palpebral aperture, and the position and permeability of the lachrymal puncta. Then passing to the region of the *tear-sac*, we see whether this is swollen, and whether pressure with the tip of the index finger causes escape of secretion, pointing to disease of the sac. We examine the condition and direction of the *cilia*, and notice whether any are misdirected.

Next we inspect the inner or *conjunctival surface of the lids*, observing any change in smoothness, thickness, and secretion of this membrane, and looking for foreign bodies.

Exposure of the conjunctiva of the lower lid is easy: Place

the thumb near the margin of the lid, press downward, while the patient looks up (Fig. 1)

Eversion of the upper lid requires a little practice: Grasp the central lashes between the thumb and index finger of the right hand and draw the lid strongly downward and away from the globe, directing the patient to look down (Fig. 2); place the left thumb (or a probe held horizontally) at the upper margin of the tarsus and press downward, at the same time quickly turning the lid Having turned the lid, it can be kept everted by shifting the left thumb against the margin, the other fingers of the left hand being applied to the patient's forehead (Fig. 3).

FIG. 1.—Eversion of Lower Lid.

Next we proceed to the *eyeball* and notice its position in the orbit, whether this is normal or whether the globe is pushed forward (*exophthalmos*) or sunken (*enophthalmos*). Its position in reference to the visual lines should be roughly ascertained. We see whether the visual lines meet at the object looked at; if they deviate, we investigate whether there is loss of motion in any direction

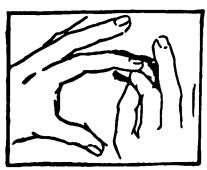

FIG. 2.—Eversion of Upper Lid.

FIG. 3.—Keeping the Upper Lid Everted.

(*paralysis*), or absence of muscle-balance (*insufficiency* and *squint*), as explained in the chapter on Disturbances of Motility.

We observe whether there is any œdema of the conjunctiva (*chemosis*), or *congestion* of the anterior part of the eyeball. If the latter is present, it should be examined

carefully, for the nature of this injection points to the seat of inflammation (p. 79).

Following this, the *cornea* is inspected, and may reveal inflammation, ulceration, vascularization, opacities, or foreign bodies. As an aid, we may now use a strong convex lens with which to concentrate the light from the window, but this method (oblique illumination) gives better results in the dark room with artificial light, and is, therefore, described in Chapter III. The *corneal reflex* derived from the window bars gives us information concerning the curvature and smoothness of this part of the eye. Placido's keratoscope (Fig. 4) a target-like disc consisting of alternate black and white circles, may be used. By having the patient look in different directions, every part of the surface of the cornea is explored; distortion of the corneal reflection of the circles or of the lines corresponding to the window panes indicates a change of curvature or roughness. A minute foreign body can often be detected in this manner.

FIG. 4.—Placido's Disc.

To bring an abrasion, infiltration, or ulcer of the cornea more clearly into view, we may instil a drop of two-per-cent. solution of *fluorescein* (p. 116), washing off the excess with water. Wherever the corneal epithelium is absent there will be a green stain.

We often find evidences of previous ulceration of the cornea in the form of *opacities*. When a corneal opacity is very faint and cloud-like, it is called a *nebula;* when denser, a *macula;* and when perfectly opaque and white, a *leucoma* (Fig. 79).

The *sensitiveness* of the cornea may be noted by means of a thread or bit of soft paper.

When there is much irritation, spasm of the lids (*blepha-*

rospasm) prevents a proper examination. In such cases, the instillation of a four-per-cent. solution of cocaine will aid us in exposing the eyeball.

In *infants or very young children*, when blepharospasm, swelling, inflammation, or obstinacy prevents us from inspecting the cornea in the usual way, the child is laid upon its back across the attendant's lap, its hands are held, and its head is steadied between the knees of the examiner (Fig. 5).

FIG. 5.—Method of Examining the Eyes of Infants and Young Children.

Under such circumstances the lids can usually be everted by pulling upon them at a little distance from the margin. To inspect the eyeball, we part the lids by placing our thumbs at the edges, rolling in the latter somewhat and then separating, keeping close to the surface of the eyeball. Having exposed the eyeball, we may replace the thumb of the right hand by the index finger of the left, thus leaving the right hand free for other uses. The eye will usually be found turned upward, and b uea will be hidden

from view; but after a minute it will appear in the palpebral aperture. Care must be taken not to scrape the cornea and cause an abrasion, nor to exert any pressure upon the eyeball, on account of the danger of perforation in case the cornea has become weakened by ulceration.

It is often necessary to use retractors (Fig. 6) in order to separate the lids under such circumstances, and with these the same caution is required against wounding the cornea or pressing upon the eyeball.

FIG. 6. — Desmarres's Lid Retractor.

The procedure just described, combined with the use of cocaine, may not be successful; then a general anæsthetic must be employed.

In all cases of forcible separation of the lids we must remember that pent-up secretions are released suddenly and may squirt into the eyes of the examiner.

Next we examine the *anterior chamber* and note its depth, whether normal, shallow, or increased, and whether the *aqueous humor* is clear; if the latter is altered, we observe whether the exudation consists of pus (*hypopyon*), blood (*hyphæma*), spongy exudation, or the like.

The *iris* comes next. We note its color, smoothness, and thickness, whether its markings are clearly defined or blurred, and whether it is steady or tremulous during movements of the eyeball. Adhesions to the cornea (*anterior synechiæ*) or to the capsule of the lens (*posterior synechiæ*) are looked for. These usually require the instillation of a mydriatic for their detection.

Then we note the characteristics of the *pupil:* size, shape, and position; also its reaction to light, and in accommodation and convergence as explained on p. 149. Behind the pupil we see the central part of the anterior surface of the *lens* and observe its transparency or any abnormal condition

which may be present, such as cataract and deposits. To explore the lens fully, dilatation of the pupil and artificial illumination are required.

PALPATION.

Palpation gives us information regarding (1) the presence or absence of *sensitiveness* in the ciliary region, and (2) the degree of *hardness* of the eyeball.

Eyeball Tension. To ascertain the *tension*, we direct the patient to look down, and then gently palpate the sclera above the cornea, by means of the two index fingers placed upon the upper lid (Fig. 7), just as in feeling for fluctuation in an abscess. We estimate the degree of tension by comparison with the other eye, if normal, or with another healthy eye. Instruments have been devised for this purpose, but such tonometers are rarely used. Increase of tension is a prominent symptom of glaucoma; degenerated conditions of the eyeball lead to diminished tension.

FIG. 7. Testing the Tension of the Eyeball.

Tension is expressed by the sign T. followed by n. when normal, by + or − when increased or diminished, with numerals indicating the degree of change, as follows:

T.n. = Tension normal.	T. − = Tension diminished.
T. + = Tension increased.	T. − 1 = Appreciable softness.
T. + 1 = Appreciable hardness.	T. − 2 = Decided softness.
T. + 2 = Decided hardness.	T. − 3 = Eyeball very soft.
T. + 3 = Board-like hardness.	

In this manner we conduct that portion of the objective examination for which daylight furnishes suitable illumi-

nation. For more minute inspection of the cornea, anterior chamber, iris, and lens, as well as for examination of the vitreous and background of the eye, we resort to oblique illumination and the use of the ophthalmoscope in the dark room, as described in Chapter III.

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CHAPTER II.

SUBJECTIVE OR FUNCTIONAL EXAMINATION OF THE EYE.

THE *subjective examination*, dependent upon the statements of the patient, comprises the testing of the function of the eye—sight.

Sight may be subdivided into (1) the *form* sense; (2) the *color* sense; and (3) the *light* sense.

The *form sense* (space sense) is the faculty which the eye possesses of perceiving the shape or form of objects, and is expressed as *acuteness of vision*. The *color sense* is the power which the eye has of distinguishing light of different wave lengths, *i.e.*, distinguishing *colors*. The *light sense* is the faculty of perceiving different degrees of intensity of illumination (*brightness*).

These three kinds of visual perceptions were formerly supposed to be represented by distinct centres in the cortical visual area of the brain, but this view is no longer held. They are present throughout the extent of the retina, though in different degrees of acuteness. We distinguish between *central and peripheral vision*.

THE ACUTENESS OF VISION.

Central or Direct Vision.—When we wish to obtain a distinct image, we look directly at an object so that the image falls upon the *macula lutea*, the portion of the retina which is adapted for the most acute vision. *The acuteness* is tested both for *distant* and for *near vision*.

Distant Vision.—In testing for distance a range of 20

feet (6 metres) is selected, since rays of light from this distance are practically parallel. For this purpose we make use of *Snellen's test types*, which are constructed upon the following principle: Each letter is inscribed within a square (Fig. 8) which subtends a visual angle of 5′ at the distance at which the normal eye should see it. The visual angle is included between two lines drawn from the extremities of the object through the nodal point of the eye (Fig. 9). Each side of the square is subdivided into five equal parts; the smaller squares thus formed subtend a visual angle of 1′, which is the minimum visual angle for the normal eye—that is, if two black objects on a white ground are separated by a space subtending a smaller angle, they will no longer be seen separate. In order to subtend the same visual angle, the size of the letters must increase the farther they are removed from the eye (Fig. 9).

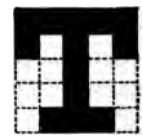


FIG. 8. — Construction of Snellen's Test Types.

Snellen's test types consist of square-shaped letters arranged upon a chart, the size of the letters diminishing from above downward. The height of each letter subtends a visual angle of 5′, the component lines a visual angle of 1′.

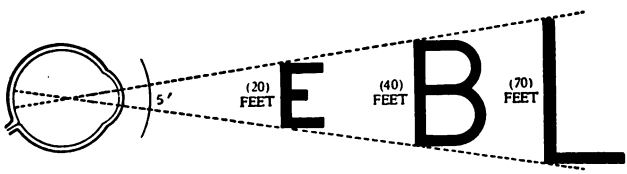


FIG. 9.—The Estimation of the Size of Snellen's Test Types at Various Distances.

The uppermost letter is of such a size that it can be read at 200 feet; then follow rows of letters which should be read at 100, 70, 50, 40, 30, 20, 15 and 10 feet respectively (Fig. 10).

The *acuteness of vision* is expressed by a *fraction*, the

numerator of which corresponds to the number of feet sep rating the patient from the chart (preferably 20 feet), a the denominator to the number indicating the distance which the smallest letters seen should be read by the no mal eye. If the patient's sight is *normal*, his acuteness vision will equal $\frac{2}{2}$'; this is expressed V. $= \frac{2}{2}\frac{0}{0}$. If can see only the third line from the top, V. $= \frac{2}{1}\frac{0}{0}$. he cannot read more than the top letter, V. $= \frac{2}{2}\frac{0}{0}\frac{0}{0}$. he reads some letters in the 50 line, but not all of th size, V. $= \frac{2}{5}\frac{0}{0}-$ or $\frac{2}{1}\frac{0}{0}+$. Many persons, especially du

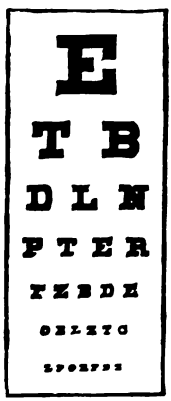


FIG. 10.—Snellen's Test Types.

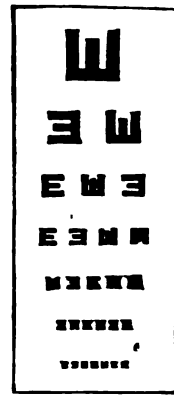


FIG. 11.—Test Types for Illiterates.

ing youth, can read the line which should be read at 1 feet, or even 10 feet, when placed 20 feet from the chart the fractions in these cases would be $\frac{2}{1}\frac{0}{5}$ and $\frac{2}{1}\frac{0}{0}$.

If the patient's vision is *less than* $\frac{2}{2}\frac{0}{0}\frac{0}{0}$, we reduce th distance from the chart. If he sees the largest letter at feet, V. $= \frac{8}{2}\frac{}{0}\frac{}{0}$. If he cannot read the top letter at an distance, we record the distance in feet or inches at whic he can correctly *count fingers ;* for example, V. = Fingers a one foot or V. = Fingers at 7 inches. If he has less sight tha this, we move the hand before the eye, and if he is capabl of appreciating such movements, we say he has "*perceptio*

of hand movements." If his vision is still further reduced, we ascertain whether he has *perception of light* (P. L.) by alternately shading and exposing the eye. This is done by means of the hand, or by throwing light upon the eye with the ophthalmoscopic mirror in the dark room, and noting whether he indicates the presence or absence of illumination.

Each eye is tested separately, one eye being covered with a card, or with the opaque disc supported in the trial frame. Daylight is the usual means of illuminating the chart, but artificial light may be used. The test types are hung opposite a window, at about the level of the patient's eyes, and the patient is placed with his back to the source of illumination. When the person is *illiterate,* we employ a series of letters E, with sizes corresponding to those of the Snellen types, in which the openings point downward, upward and to the right and left (Fig. 11); the acuteness of vision is then fixed by the smallest row of which the patient can correctly tell the direction in which the figures are open.

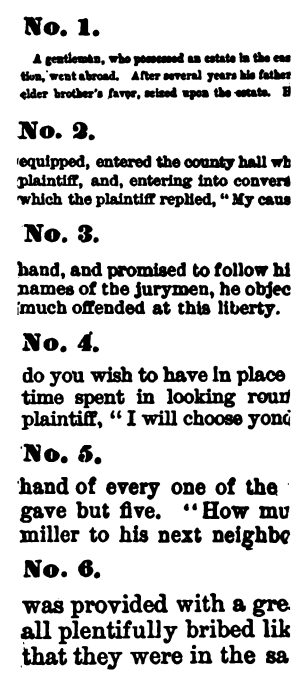


FIG. 12.—Jaeger's Test Types for Near Vision.

Near Vision.—When in a state of rest, the eye is adapted for parallel rays coming from a distant object. In order that divergent rays from a near object shall be focussed on the retina, there must be an increase in the refractive power of the eye; this change is known as *accommodation;* it will be more fully described in Chapter XXII.

The test types usually employed to determine near vision consist of different sizes of ordinary printer's types; the finest is numbered 1, successive numbers indicating coarser types. They are known as *Jaeger's test-types* (Fig. 12).

The patient should be placed with his back to the light, so that the page is well illuminated, and each eye tested separately. His near vision is expressed by J., followed by the number corresponding to the finest print which he can read; thus, J. 1 means that the patient is able to read the third paragraph.

THE FIELD OF VISION.

Peripheral vision is exercised when the image falls upon some part of the retina outside the fovea centralis; such vision is indistinct, but of great importance.

The field of vision represents the limits of peripheral or indirect vision; it is the space within which an object can be seen while the eye remains fixed upon some one point. It usually refers to one eye, the other being covered, and, when not otherwise stated, applies to a white object. The field can be outlined roughly by the *hand*, more accurately by a piece of chalk upon a *blackboard*, or a lighted *candle*, most exactly by means of a *perimeter*.

The Hand Test.—The patient is turned with his back to the light, and the examiner faces him at a distance of two feet. After covering one eye, the patient is directed to fix the eye of the examiner, which is opposite. The hand with extended fingers is then moved from various parts of the periphery inward, and the patient indicates when he sees the fingers. In this way the examiner can compare the patient's field with his own; if both be normal, patient and examiner must see the fingers simultaneously. This is a very simple and rapid method, and is sufficiently accurate when there are gross changes in the field. Instead of the hand, a small white knob upon the end of a rod may be used to measure the field.

The Candle Test.—When the patient is no longer able to see the hand, we make use of a lighted candle, in the same manner, in the dark room.

The Blackboard Test gives us an approximately correct graphic representation. The patient is placed 12 inches in front of a blackboard, upon which we mark a cross to serve as the point of fixation. A piece of chalk is now gradually brought from the periphery toward the centre, and the patient indicates when he sees it in the several directions. These points are marked, and by connecting them an outline of the field is obtained.

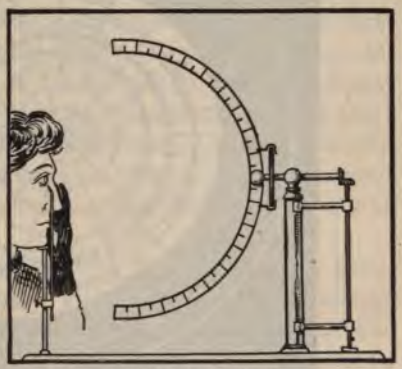


FIG. 13.—The Perimeter.

The Perimeter (Fig. 13) furnishes the most exact method. It consists of a metallic semicircle, which can be revolved so as to take the direction of any meridian. This arc is marked in degrees, 0 corresponding to the middle point and 90 to either extremity. The patient's head is supported upon a chin-rest, one eye closed, and the other fixed upon an object placed at the centre of the arc. The test object, a piece of white paper 10 mm. square, is carried along the inner surface of the arc, and the points where it is first seen in the different principal meridians are marked upon diagrams of the normal field; the lines connecting these form the boundary of the field.

Extent of the Normal Field of Vision.—Toward the temporal side it is 90° (or over); in other directions it is less extensive, on account of the more anterior termination of the percipient layers of the retina on the nasal side. On

the nasal side the field extends 60°; above, 60°; below, 70° (Fig. 14).

Pathological Alterations in the Field of Vision.—These consist of *limitation* and *defects*. Limitations may assume the form of contraction evenly in all directions (*concentric*)

FIG. 14.—Normal Fields for White and for Colors (Blue, Red, and Green).

(Fig. 136), *irregular* contraction (Fig. 93), or loss of part of the field on *one side or the other* (Fig. 138).

Concentric contraction affects all parts of the periphery alike; when considerable, nothing but central vision may remain (Fig. 136); such contraction with preservation of good central vision is met with especially in retinitis pigmentosa. The contraction may affect only *one side* of the periphery; in such cases we speak of temporal or nasal contraction, or upper or lower contraction. When *one-half* of the field is absent (Fig. 138), it constitutes *hemianopsia* (p. 258). *Sector-shaped* contractions sometimes exist; the defect then has the shape of a triangle the base of which

is peripheral. Certain affections produce characteristic contraction of the visual field; for instance, in atrophy of the optic nerve the contraction is concentric; in glaucoma, it is greatest on the nasal side.

A scotoma is a defect within the visual field. A physiological scotoma is the *blind spot*, the situation of which is about 15° to the outside of the point of fixation, corresponding to the entrance of the optic nerve (the black spot in Fig. 14). According to their situation, we divide scotomata into *central* and *peripheral*. *A central scotoma* corresponds to the point of fixation; when marked, it interferes with or abolishes central vision altogether; the scotoma accompanying hemorrhage at the macula furnishes an example. *Peripheral scotomata* cause little disturbance of sight and may exist without the patient's knowledge, especially when situated far from the point of fixation; disseminated chorioiditis furnishes numerous examples of scotomata of this sort.

Scotomata may be *positive*, when the patient sees them as black spots in his field, or *negative*, when they exist as defects in the visual field, but are not perceived by the patient until the visual field is examined. Positive scotomata are due to changes in the media or in the retina. If the opacities exist in the vitreous, the scotomata are *motile;* muscæ volitantes represent one variety of defects of this sort. Negative scotomata may be total or *absolute*, when perception of light is entirely lost over the defective area, or *relative*, when there is only diminished perception of light, or loss of perception of certain colors over this area. Toxic amblyopia gives us an example of a scotoma which is central and relative.

THE COLOR SENSE.

Just as in the case of the form sense (acuteness of vision), we distinguish between *central* and *peripheral perception of color*. The former is tested by the exhibition of samples

of colored wool (p. 255), the latter by small objects, such as squares of colored paper or small colored knobs 10 mm. in diameter, which are moved from the periphery toward the centre, on the perimeter or in the coarser methods of testing the field.

The field for colors is smaller than that for white, but has the same general shape. It varies also for different colors; that for blue is the largest, next comes red, while green has the smallest field. The limits (given in Fig. 14) correspond to the points at which the *colors are recognized*, not to those points at which merely the presence of a moving object is perceived. The examination of the color fields is of *considerable importance*, since we frequently find that contraction of the field for colors exists at an earlier period than that for white. It is a more delicate test, and detects diminution of visual power before it has become sufficiently pronounced to affect the field for white.

THE LIGHT SENSE.

The power of perceiving gradations in intensity of illumination (brightness) is tested by means of instruments known as photometers. We determine either the *smallest degree of light* with which an object is still visible, or the *smallest difference in illumination* which can be appreciated. The estimation of the light sense has not yet found practical utilization in ophthalmology; but experiments seem to indicate that it may before long be of advantage in diagnosis. Diminution in the light sense is not always proportionate to changes in the acuteness of vision. Marked reduction of the light sense is seen in cases which are acccompanied by night blindness (hemeralopia),—retinitis pigmentosa, for instance.

The examination of the *motility of the eye* is described in Chapter XXV.

CHAPTER III.

OBJECTIVE EXAMINATION OF THE EYE CONDUCTED IN THE DARK ROOM. OBLIQUE ILLUMINATION AND THE OPHTHALMOSCOPE.

THE *examination in the dark room* comprises the following steps, which are best taken in the order given:

I. *Oblique illumination*, for the physical examination of the *anterior portions of the eyeball.*

II. *Examination with the ophthalmoscope at a distance*, for exploring all the *media* of the eyeball.

III. *The indirect method of ophthalmoscopy*, for examining the *fundus*, giving an *inverted* picture of *low magnification.*

IV. *The direct method of ophthalmoscopy*, for examining the *fundus*, giving an *erect* picture of *greater magnification.*

The best results with these methods are obtained when the examining-room is perfectly *dark.* The source of illumination usually preferred is an *Argand gas burner* upon a "*universal bracket*," which permits the flame to be placed on either side of the patient, and to be raised or lowered at will. Patient and examiner may be either standing or seated.

OBLIQUE ILLUMINATION.

Oblique, lateral, or focal illumination furnishes a very valuable means of minutely *exploring the cornea, anterior chamber, iris, and lens.* By means of a *strong convex lens* of two- or three-inch focus, light is concentrated upon the eye in such a manner that the apex of the cone corresponds to the part to be examined (Fig. 15). The source of illu-

mination should be about eighteen inches to the side of the patient, several inches in advance, and on a level with the eye. The lens is grasped by its margin between the thumb and index finger, held so that its surfaces are at right angles to the direction from which the light proceeds, and steadied by means of the little finger placed against the side of the patient's face. After having examined one eye, without removing the supporting finger, we turn the patient's head slightly toward the light and illuminate the

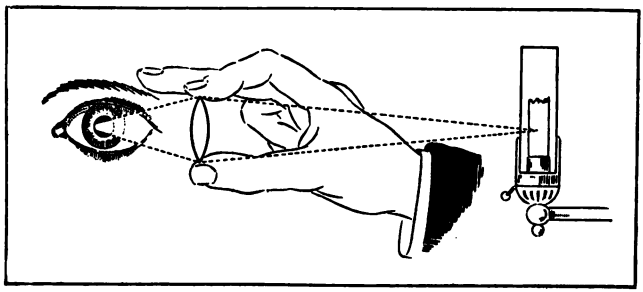


FIG. 15.—Oblique Illumination.

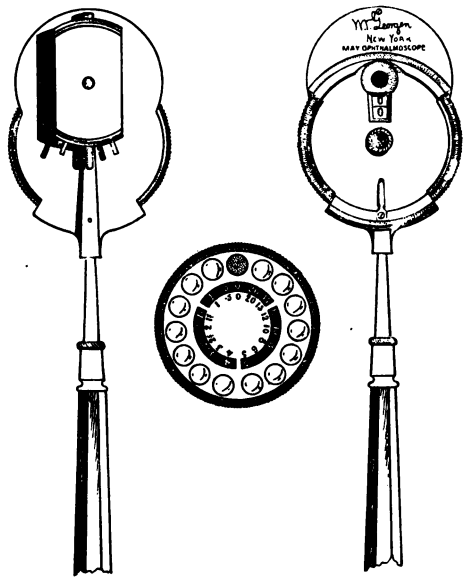
opposite eye. The flame may be placed on either side; if on the patient's right, we use the left hand for holding the lens; if on the left, we use the right hand. After having examined the cornea the lens is brought nearer to the eye, so that the apex of the cone of light corresponds to the deeper structures which we wish to explore.

With a second strong convex lens held at its focal distance (two or three inches) in front of the patient's eye, we can magnify the illuminated area and thus obtain greater detail.

Opacities of the cornea, aqueous, or lens, seen by oblique illumination, appear as *grayish* or white *spots* upon the *black ground* of the pupil.

THE OPHTHALMOSCOPE.

The ophthalmoscope (Figs. 16, 17, 18) was invented by Helmholtz in 1851. Previous to this period we had practically no knowledge of the interior of the eye during life.



FIGS. 16, 17, 18.—The Author's Ophthalmoscope. Fig. 16, Mirror side; Fig. 17, lens disc; Fig. 18, rear side.

The essential portion of this instrument is a *perforated mirror*. This is mounted upon a convenient handle and supplemented behind by a disc containing *convex and concave lenses*.

The mirror (Fig. 16) serves to reflect light into the interior of the eye, while the aperture allows a portion of this light, after returning from the patient's eye, to pass into that of the observer. The mirror commonly employed is

concave, glass of low index, focus, either circular or of the form of a parallelogram, which allows it to be tilted to the right or left.

The [illegible] is placed behind the mirror and provided with a [illegible] of lenses, which follow each other in regular order from the weaker to the stronger. By means of the [illegible] with a milled edge the disc can be rotated so that any [illegible] behind the perforation in the mirror [illegible] a number indicating its focus. [illegible] manufacture the *convex* or + lenses are [illegible], the *concave* or − lenses in [illegible].

THE OPHTHALMOSCOPIC EXAMINATION.

Before attempting to see the fundus, we must explore the *media*. This preliminary step is important, since it will explain modifications in the picture obtained by subsequent methods, or failure to see the fundus in cases in which changes in the media exist. One mode of obtaining such information, oblique illumination, has already been described; it is particularly applicable to the anterior media. A second method is

EXAMINATION WITH THE OPHTHALMOSCOPE AT A DISTANCE.

This method explores *all the media*,—cornea, aqueous, lens, and vitreous. The light is reflected from the mirror into the eye, and, returning from the background, traverses the media before reaching the eye of the examiner through the aperture in the mirror.

The source of illumination is placed on either side of the patient, on a level with the eye and several inches to the side and behind, so that the light strikes the patient's temple, leaving his face in darkness. The patient faces the examiner, the latter standing or sitting directly in front.

The ophthalmoscope is held in front of either eye of the observer, so that he can look through the perforation, and is steadied against the side of the nose and supraorbital margin. The distance between patient and examiner is about *fifteen inches.*

From the mirror the light is reflected into the eye of the patient. Reaching the background, it is *colored* orange-red by contact with the chorioidal vessels and retinal and chorioidal pigment. This tinted light returns through the patient's eye and enters the eye of the examiner by means of the aperture in the mirror. The *exact tint varies* with the color of the background of the individual, depending upon the abundance of chorioidal and retinal pigment; hence it is brighter in persons of light complexion, and darker in others. It is also influenced by the amount of illumination, and consquently the reflex is brighter when the pupil has been artificially dilated. The patient is told to move the eyes in various directions, and in this manner all parts of the media are explored.

In the normal eye a *homogeneous orange-red reflex* (*fundus reflex*) is obtained. If any *details* of the vessels of the fundus are seen, the eye is *ametropic.* If, when the observer moves his head from side to side, these vessels appear to move in the same direction, the eye is hypermetropic; if in the opposite direction, it is myopic.

If *opacities* exist in any of the media, they will appear as *dark* or black *spots* upon the colored background of the pupil. They are dark because they intercept a certain part of the light.

Opacities of the media may be either *fixed,* in which case they move only with the eye, or *movable* (floating), when they float about after the eye has been rapidly moved and then suddenly stopped; the latter occur only in the vitreous. The exact *situation of opacities* of the media can often be estimated by oblique illumination. Another method consists in noting the *displacement of the opacity with regard*

...server's head is moved slowly from ... there is no apparent motion of the ... of the iris: when it appears to ... it is in front: and when in ... this plane. A third method ... *motion of the opacity to* ... the patient moves his eye, the ... same direction as) the eye, it ... of rotation of the globe ... portion of the vitreous, ... the retina): if it moves in the ... behind this point; if it has ... at the centre. In both of ... apparent motion the more re... plane of the iris and the con... tively.

... the media and iris may be ... *lenses* (from 5 to 20 D.) in the sight ... gradually approaching the eye as the strength of the lenses is increased.

Having ascertained the condition of the media, we proceed to ... The expert may succeed with a pupil of natural size, but it is often wise, and not infrequently necessary, to ... Moderate dilatation is secured by instilling one drop of a four-per-cent. solution of *cocaine*; after fifteen minutes the pupil will be of sufficient size, and the effects will pass off in half an hour, thus causing no discomfort to the patient. A five-per-cent. solution of *euphthalmin* acts more energetically, with no greater inconvenience. Greater dilatation follows the instillation of one drop of a two-per-cent. solution of *homatropine*, or of a mixture of two per cent. *homatropine* and one per cent. *cocaine*; these cause mydriasis in from twenty to thirty minutes, and the effects last twenty-four hours.

There are two methods of examining the fundus: (1) the *indirect*, (2) the *direct*.

THE INDIRECT METHOD OF OPHTHALMOSCOPIC EXAMINATION.

With the indirect method we obtain an *inverted image* of the fundus, *magnified* about *four diameters.* The source of illumination is in the same position as when we examine the media—behind, to the side, and on a level with the eye —and the examiner and patient retain the same relative

FIG. 19.—Indirect Method of Ophthalmoscopic Examination.

positions. In the aperture of the ophthalmoscope we place a *3 or 4 D. convex lens,* which enables the examiner to obtain a clear image with his accommodation at rest. Placing the ophthalmoscope before either eye, at a distance of about 15 inches from the patient, we obtain the fundus reflex. A strong convex lens of about two inches focus (called the *objective lens*) is now held at about its focal distance in front of the eye to be examined. This lens is grasped at its edges by the thumb and index finger of the left hand and steadied by placing one of the other fingers against the forehead of the patient (Fig. 19). If a clear view of some part of the background is not obtained, we vary the distance from the patient by slowly moving the head back-

ward or forward, until there appears a distinct aerial, inverted image of the fundus at a short distance in front of the lens, corresponding to its focus.

After having seen the right fundus, we proceed to the examination of the left, without making any change in the position of the light, ophthalmoscope, patient, or examiner. We merely move the lens so as to cover the patient's left eye, now steadying it with the middle finger placed upon the forehead; the little and ring fingers are flexed into the palm of the hand, so that they will not obstruct the right or free eye of the patient and thus prevent him from gazing in any direction which we indicate. In the examination of the left eye we may, if we prefer, hold the ophthalmoscope in the left hand and the lens in the right.

We always begin the examination by looking for the *entrance of the optic nerve* (the *disc* or *papilla*), this being the most prominent feature of the background. The optic-nerve entrance is a little to the inner or nasal side of the visual axis; hence, in order to bring it into view, it is necessary to direct the patient to *move the eye in* somewhat, which will rotate the posterior pole of the eyeball outward. When we are directly in front of the patient, this is accomplished by having him look *over* our right *shoulder*, on a level with the upper border of the ear, when we examine the right eye, and over our left shoulder on a corresponding level, when we examine the left eye.

To see the *parts surrounding the disc*, we move the lens or the head slightly in various directions, always remembering that the image is inverted and moves in the opposite direction to that taken by the lens or head. More peripheral parts are brought into view when the patient moves his eye up, down, to the right, and to the left.

When the patient looks directly at the ophthalmoscope, it brings the *macula* into view; but since he must accom-

modate when fixing so near an object, the pupil will contract. On this account it is necessary to dilate the pupil when we wish to get a view of the macular region with the indirect method.

The beginner may encounter a *number of difficulties* in using the indirect method. He may have trouble in bringing the disc into view, because the patient persists in watching the ophthalmoscope instead of looking across the examiner's shoulder. Owing to defects in the manufacture of the instrument, there are often very *bothersome reflexes* from the margins of the sight-hole and perforation of the mirror. There is frequently a very *annoying reflection* of the flame from the cornea or from the surfaces of the lens which we hold before the patient's eye. These reflexes may be obviated by a slight inclination of the lens, a change in the angle of the mirror, or a little variation in the position of the examiner or source of illumination, which experience alone will teach us.

THE DIRECT METHOD OF OPHTHALMOSCOPIC EXAMINATION.

With the direct method we obtain an *erect* picture of the fundus *magnified* about *fourteen diameters.*

The examiner sits or stands to the side of and facing the patient (Fig. 20). The ophthalmoscope is supported as in previous methods, and brought directly in front of the patient's eye as close as possible. There should not be a greater distance than an inch between the eye of the patient and that of the observer. The light occupies about the same position as in previous methods.

When we examine the *right eye,* the examiner and the light must be on the *right side,* and consequently the ophthalmoscope must be placed before the right eye of the observer. When the left eye is being examined, the light and examiner must be to the left, and the observer must use his

left eye. When the ophthalmoscope is provided with a tilting mirror, the surface of the latter must be turned toward the source of illumination.

When both examiner and patient are *emmetropic*, and both relax their accommodation, the observer looks through the sight-hole and obtains a *clear view* of the fundus without any lens. The patient is told to look at the opposite

FIG. 20.—Direct Method of Ophthalmoscopic Examination.

wall, directly forward, over the shoulder of the examiner. This brings the *disc* into view. The parts around the disc are next examined. The periphery of the fundus is brought into view when the patient looks in various directions. The *macular region* is found to the outer side of the disc, the distance corresponding to about twice the diameter of the papilla. When the pupil has been artificially dilated so that it cannot contract in accommodation, the macula can also be brought into view by having the patient look into the aperture of the mirror.

The *size* of any particular lesion is *compared with* that of the *disc*. Elevations of the fundus or of new growths are

measured in diopters; an elevation of 1 mm. corresponds to 3 D.

The examiner is often annoyed by *reflexes* from the margins of the sight-hole and mirror perforation and from the cornea. The former are due to defects in the ophthalmoscope. The latter can be obviated by a slight change in the angle of the mirror, the position of the examiner or that of the light.

When either patient or examiner is *ametropic*, it will be necessary to rotate one of the *lenses* in the disc with which the ophthalmoscope is provided, behind the mirror opening, in order to neutralize the error of refraction and thus render a perfect view of the fundus possible. If the observer be ametropic, he must either wear his correcting distance glasses or have a special correcting lens fitted behind the aperture, or he may rotate his correcting lens before the aperture from one of those contained in the disc of the instrument. When the patient is *ametropic*, a *suitable lens* must be rotated into place behind the aperture before a clear picture of the fundus is obtained; if he is *myopic*, this will be the *weakest concave* lens, and if *hyperopic*, the *strongest convex* lens, which will give a distinct picture. This gives an indication of the manner in which the direct method is employed for the *estimation of errors of refraction*.

In the direct method the observer must *relax his accommodation* in order to obtain a perfectly distinct image of the fundus. The beginner often finds this *difficult*, since he cannot forget that he is looking at a very near object, and he accommodates accordingly. He is very apt to place a concave lens of about 4 D. in the sight-hole to neutralize the effects of such efforts, even though the patient has no myopia. Relaxation of accommodation is absolutely indispensable in using the direct method for the purpose of estimating errors of refraction. It is encouraged by *keeping both eyes open* and looking in the distance with the uncov-

...ing the accommodation is ... the usual reading dis... becomes blurred and ... to cultivate the habit.

The Indirect and Direct Methods Contrasted.—The *indirect* ... a *larger field*, though a *smaller* ... presents a *general view* of the ... be used successfully ... the patient's eye. On ... we are often able to get ... when slight opacities of the ...

... other hand, gives us an *erect* ... *magnified*, though a *smaller* ... at a time; hence it permits of ... parts to which our ... by the indirect method. It is ... ophthalmoscope for the esti...

Theory of the Ophthalmoscope.—As ordinarily seen, the ... which leaves it is ... from which it came. If the eye of the ... so as to intercept the returning rays, the pupil of the observed eye will appear illuminated. With the ophthalmoscope light is reflected into an eye under examination, and the observer's eye is placed in the path of the returning rays and receives some of these through the perforation in the mirror.

Fig. 21 explains the illumination of the interior of the eye with the *ophthalmoscope at a distance*. E represents the eye of the examiner and P that of the patient. Divergent rays of light, proceeding from the Argand burner L, strike the ophthalmoscopic mirror O, are reflected and made convergent, passing into the eye P, crossing in the vitreous, and illuminating the fundus between A and B. From any point of this illumin... C for instance, rays are re-

flected, pass out of the eye, being made parallel by its refracting apparatus, and proceeding, pass through the aperture of the mirror O into the eye of the examiner E. The

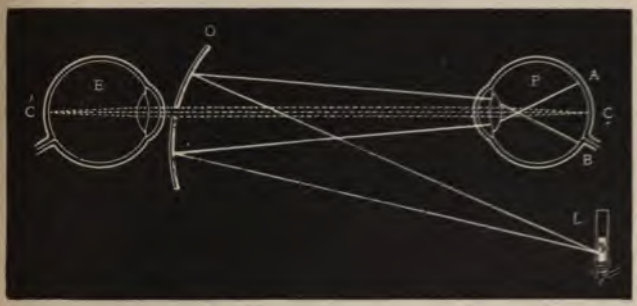


FIG. 21.—Ophthalmoscopic Examination at a Distance.

dioptric apparatus of E brings these rays to a focus on the retina, and they form at C' an image of C.

Fig. 22 explains the *indirect method*. From L divergent rays proceed to the mirror O, are reflected and made con-

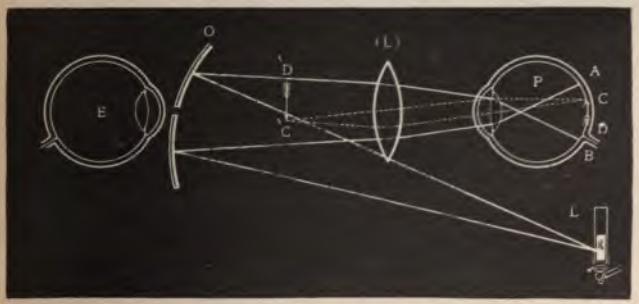


FIG. 22.—Indirect Method of Ophthalmoscopic Examination.

vergent, passing into the examined eye P, crossing in the vitreous. They illuminate the fundus between A and B. From any portion of this illuminated area, C D for in-

Fig. 25.—Direct Method of Ophthalmoscopic Examination.

vergent, passing into the examined eye E, crossing in the vitreous. The fundus from A to B is lighted up. From any portion of this illuminated area, C D for instance, rays are reflected, pass out of the eye P, being made parallel by its dioptric apparatus, through the perforation of the mirror O, into the eye of the examiner E. Here they are brought to a focus on the retina. They are convergent, and being prolonged backward, form a magnified and erect *image of C D*, behind the eye of the patient P, at C' D'.

THE NORMAL FUNDUS.

The normal fundus exhibits a great many *variations* in *details*. It *presents an orange-red* surface, upon which we *distinguish the disc*, the *blood-vessels*, and the *macula* (Fig. 26, *Plate I.*)

The *Disc* or *Papilla* represents the *entrance of the optic nerve;* it is usually circular, but sometimes oval in form. Its color is light pinkish, more pronounced over the inner half, the outer portion being paler. The disc is much lighter in color than the rest of the fundus, and is separated from adjacent portions by a *sharply-defined margin*, especially at the outer side. This margin often presents two rings: an inner, the *scleral* (*s*, Fig. 24), of white color, formed by exposure of the sclera when the opening in the chorioid is larger than that in the sclera, and an external ring, the *chorioidal* (*c*, Fig. 24), of dark color, formed by an accumulation of pigment at the margin of the aperture through which the optic nerve passes. This pigmented ring may be complete or incomplete. In the latter case it is generally found at the outer border. The margins of the normal disc are occasionally slightly indistinct, especially above and below. This appearance is sometimes seen in hyperopic eyes of young subjects, and must not be mistaken for neuritis.

FIG. 24.—Ophthalmoscopic View and Longitudinal Section of the Disc. *a*, Central artery; *v*, central vein; *E*, physiological excavation; *s*, scleral ring; *c*, chorioidal ring; *r*, retina; *ch*, chorioid; *scl*, sclera.

The centre of the papilla presents a *funnel-shaped depression* (E, Fig. 24), formed by the separation of the nerve fibres. This appears whiter than the rest of the disc. It is known as the "*physiological depression*" or "*cup.*" It may be comparatively large and occupy one-half or more of the disc, but never the entire papilla, in which respect

it differs from the pathological excavations of glaucoma and of optic-nerve atrophy (Figs. 94, 95, 96). At the bottom of this physiological excavation, when marked, we frequently see grayish spots. These represent the openings in the lamina cribrosa, the connective-tissue layer through which the fibres of the optic nerve pass.

The Central Artery and Vein of the optic nerve (*a* and *v*, Fig. 24) pass along the inner wall of the excavation, and upon reaching the surface of the disc usually divide into *superior and inferior branches;* each of these soon divides and subdivides, giving off *nasal and temporal branches;* from these, smaller twigs are derived which become terminal and do not anastomose. Small branches are often given off from the main trunks and pass across the disc. The macular region is devoid of larger vessels, though finer branches are seen to approach this area. The *arteries* are readily distinguished from the veins by their *smaller* calibre, *bright red* color, and *straighter* course. They present a *bright reflex* running along the centre. The *veins* are of *greater thickness*, of a *darker* red color, *more tortuous*, and the light streak is fainter. Arteries and veins usually follow the same course. The veins frequently present a distinct *pulsation*, most marked where the central trunk appears on the disc, and increased by pressure upon the eyeball; this is physiological. Pulsation in the retinal arteries, on the other hand, is pathological, and occurs in glaucoma, cardiac disease, and in profound anæmia.

The Retina itself is *transparent*. The *color of the background* is derived from the chorioidal vessels, and modified by the pigment-epithelium layer of the retina and the pigment of the chorioid. It is *bright orange-red* in persons of *fair complexion*, while in *darker individuals* it has a *deeper, brick-red* color. The fundus presents a granular or *stippled* appearance, caused by the pigment cells. When the pigment-epithelium layer of the retina is well developed, the chorioidal vessels cannot be seen. More often, considerable

FIG. 25. Normal Fundus. Average Tint.

FIG. 26.—Normal Fundus in an Individual of Dark Complexion.

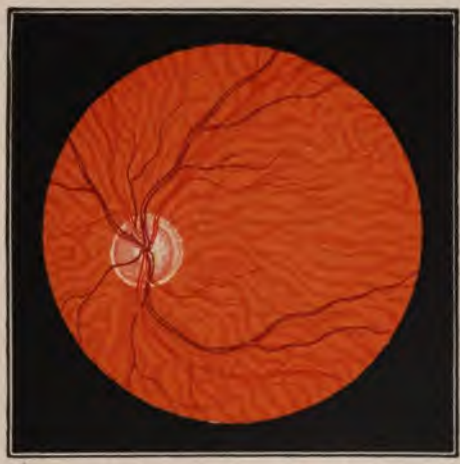


FIG. 27.—Normal Fundus in a Person of Light Complexion.

FIG. 28.—Opaque Nerve Fibres.

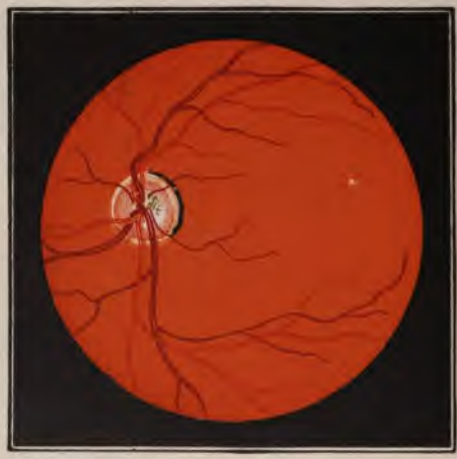


FIG. 25. Normal Fundus. Average Tint.

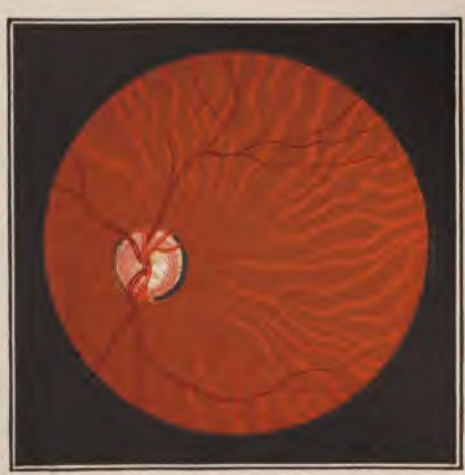


FIG. 26.—Normal Fundus in an Individual of Dark Complexion.

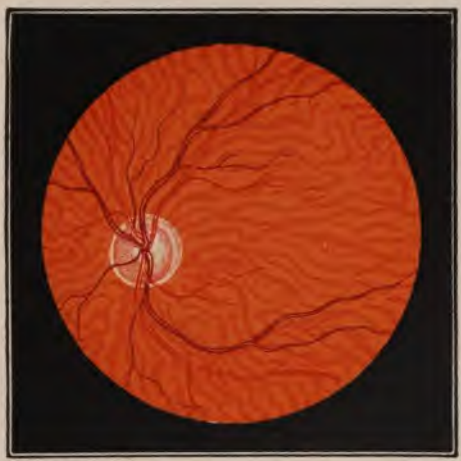


FIG. 27.—Normal Fundus in a Person of Light Complexion.

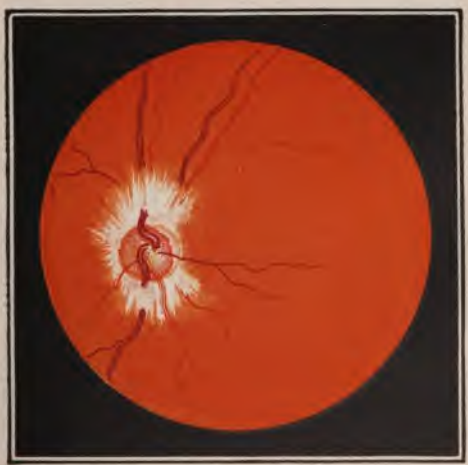


FIG. 28.—Opaque Nerve Fibres.

detail of the *vessels of the chorioid* will be visible. This occurs under two conditions: In some cases there is no obscuration by the pigment layer of the retina, and the chorioidal pigment is very abundant and collected into the intervascular spaces; then these stand out as dark islands separating bright-red lines and bands, which anastomose freely, the chorioidal vessels (Fig. 26, Plate I.). In other instances there is very little pigmentation in either retina or chorioid, allowing the chorioidal vessels to be seen plainly, now presenting the picture of bright-red anastomosing channels with brighter interspaces (Fig. 27, Plate II.). The *chorioidal vessels* are most markedly visible in the periphery, and are readily distinguished from retinal vessels by being less sharply defined, flat, having no light-streak, and by their free anastomosis.

The Region of the Macula Lutea, physiologically the most important part of the fundus, is situated rather less than two disc-diameters to the temporal side of the entrance of the optic nerve, in the line of direct vision. Very often this region presents scarcely any distinctive feature. It is always *devoid of visible vessels*, and is somewhat *darker* than the rest of the fundus. Frequently a *bright spot* is seen in its centre corresponding to the position of the *fovea centralis*, or there may be two or three of these bright spots. Sometimes the macular region is represented by a bright spot surrounded by an area of dark-red color, about the size of the disc, oval horizontally, and this again encircled by a *bright halo;* this reflex is best seen in the indirect method and is most marked in children of dark complexion, especially if they be hyperopic.

Physiological Variations.—In children of dark complexion the fundus not infrequently presents a bright lustre, which changes its position with movements of the mirror. It is most marked along the blood-vessels; it resembles the shimmer of *watered silk*. Another peculiar but physiological appearance is sometimes occasioned by *opaque nerve*

fibres. In such cases the axis cylinders of some of the optic-nerve fibres regain their medullary sheath at the disc, and continue in this condition for some distance beyond the papilla, presenting one or more whitish areas extending for a variable distance from the disc and terminating in brush-like extremities (Fig. 28, Plate II.).

CHAPTER IV.

AFFECTIONS OF THE EYELIDS.

Anatomy and Physiology.—The eyelids consist of movable folds formed, from before backward, of skin, loose connective tissue, muscular tissue, tarsus and fascia, and conjunctiva. In addition, they present eyelashes, numerous glands, blood-vessels, lymphatics, and nerves.

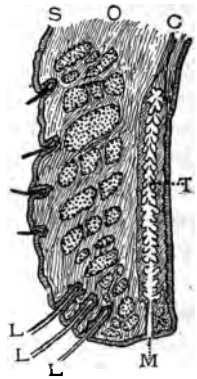


FIG. 29.—Longitudinal Section of the Upper Lid. *S*, Skin; *O*, orbicularis muscle; *C*, conjunctiva; *T*, tarsus; *M*, opening of Meibomian gland; *L*, lashes.

The *integument* is thin and delicate, and joined to the subjacent muscles by loose areolar tissue, free from fat. These characteristics explain the readiness with which extravasations of blood and œdematous swellings occur in this region.

The *margin* of each lid presents in front the *eyelashes* (*cilia*), which form two or three rows of short, thick, curved hairs, their roots deeply embedded in the connective tissue and muscle; they are provided with sebaceous follicles, known here as Zeiss' glands. Behind, the lid margin presents the openings of the *Meibomian glands*, and in front of these the openings of modified sweat-glands, the glands of Moll. The margins of the lids unite at an acute angle externally (*external canthus*). At the *internal canthus* the junction presents a rounded space which is occupied by a small, reddish elevation of modified skin, the *caruncle*.

In and behind the subcutaneous connective tissue we find the *muscles* of the eyelids. The *levator palpebræ superioris* is attached to the upper border and anterior surface of the tarsus and to the skin of the middle of the upper lid. The orbicularis muscle lies between tarsus and integument, being attached to the latter, but gliding loosely over the former. We also find a layer of *unstriped muscular tissue* inserted into the upper border of the tarsus and known as Mueller's muscle.

The *tarsus* consists of a thin plate of dense fibrous tissue, giving to each lid its firmness; it is larger in the upper than in the lower lid. The tarsi are connected with the lateral walls of the orbit by means of the internal and external *tarsal ligaments*, and to the upper and lower margins by an aponeurotic layer of fibrous tissue known as the *palpebral fascia* or ligament. In the substance of the tarsus, occurring in parallel rows, are found the *Meibomian glands*, thirty to forty in the upper and twenty to thirty in the lower lid. These are elongated sebaceous glands with blind extremities and numerous cæcal appendages, filled with fatty secretion, and opening on the free margin of the lid.

The *palpebral conjunctiva* is thin, vascular, and closely adherent to the tarsus.

The *arterial supply* of the lids is derived principally from the ophthalmic artery. The *veins* empty into the ophthalmic, temporal, and facial. The *lymphatics* pass to the preauricular, submaxillary, and parotid lymphatic glands The *third nerve* supplies the levator, the *facial* the orbicularis, and the sympathetic the unstriped muscular tissue (Mueller's muscle). The *sensory nerve* supply is derived from the *fifth*.

The lids *protect the eyes* from external injury, foreign bodies, undue exposure, and excessive light. They serve to distribute the tears and the secretions from the various glands, thus lubricating the eyeball, keeping the surface of the cornea moist and transparent, and washing away any minute substances which may have gotten into the eye.

The Common Affections of the Eyelids are blepharitis, hordeolum, chalazion, trichiasis, entropion, ectropion, ptosis, tumors, and injuries.

BLEPHARITIS.

A very *common*, chronic inflammatory condition of the margin of the lids, associated with the formation of *scales and crusts* (Fig. 30). It occurs under two forms: (1) *non-ulcerative*, (2) *ulcerative*.

FIG. 30.—Blepharitis.

Symptoms.—In the *superficial* or *non-ulcerative form*, the *margins* of the lids are *swollen* and *reddened*, and present numerous whitish *scales* at the bases of the lashes. The latter fall out readily, but are replaced, since there is no destruction of the hair follicles.

In the *deep* or *ulcerative form*, the *edges* of the lids are *reddened* and *swollen*, and present yellowish *crusts* which glue the lashes together. On removing these crusts small *ulcers* are seen about the attachments of the lashes; these ulcers bleed readily. The lashes become *distorted*, *fall out*, and grow scarce, since they are not replaced on account of destruction of the hair follicles. In both forms there will be *itching*, *soreness*, *epiphora*, and *sensitiveness to light*.

Sequelæ occur especially in the ulcerative form. There may be permanent *loss* of a greater or lesser number of *lashes*, *hypertrophy* of the lid margin, *trichiasis*, and *ectropion*.

Etiology.—*Poor hygienic surroundings; debilitated* conditions of the system; following the *exanthemata*, especially measles; exposure to *irritating atmosphere*—smoke, wind, dust; late hours; insufficient sleep; uncorrected *errors of refraction*, especially hyperopia and astigmatism; chronic *conjunctivitis;* lachrymal disorders; lack of cleanliness.

The disease occurs at all ages, but is very common in *children.*

Treatment.—The disease is apt to be obstinate. *Removal of the cause*, if possible, is of the greatest importance. *Cleanliness*, change of faulty habits, and correction of errors of refraction are great aids to local treatment. The edges of the lids must be *cleansed* thoroughly with soap and water, *freed* from all scales and crusts, dried, and then covered with the *ointment of the yellow oxide of mercury*, or of ammoniated mercury. To remove the crusts, soap and water, or water to which a little borax has been added, should be used and applied upon cotton. In the ulcerative form an occasional application of one- or two-per-cent. solution of *silver nitrate* to the raw spots will prove useful. In severe and long-standing cases it will be necessary to *pull out all the lashes*, and then to apply the treatment given above.

HORDEOLUM OR STYE.

A *circumscribed, acute* inflammation of the *tissues about the follicle of an eyelash*, generally ending in *suppuration.*

Symptoms.—A *red swelling* (Fig. 31, lower lid) appears at the *margin of the lid*, accompanied by pain, tenderness, and often by considerable œdema. Very soon a *yellowish point* will be seen, indicating suppuration.

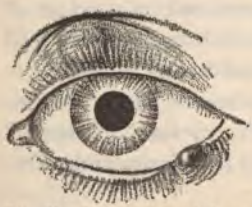


FIG. 31.—Hordeolum of Lower Lid, Chalazion of Upper Lid.

Etiology.—Styes occur at *all ages.* They are very *common* in young adults. They often appear in *crops* They are frequently associated with a *deranged condition* of the system, constipation, and uncorrected *errors of refraction*

Treatment.—It is sometimes possible to *abort* a stye by the use of cold compresses. As a rule, however, this is unsuccessful. *Hot compresses* are then indicated to hasten

suppuration. As soon as a yellow spot is seen, the *pus* should be *evacuated* either by pulling out one or more lashes or by a horizontal incision. To prevent the formation of others, the *general health* should be looked after and *errors of refraction* corrected. *Calcium sulphide*, gr. $\frac{1}{8}$ t.i.d., or syrup of the *hypophosphites* with iron, ʒ i. t.i.d., may be of service.

CHALAZION.

Chalazion (*tarsal tumor, tarsal cyst, Meibomian cyst*) is an *enlargement* of one of the *Meibomian glands* in consequence of stoppage of its duct, accompanied by a *chronic inflammation in the surrounding tarsus.* It occurs most frequently in adults. Very often several are found at the same time.

Symptoms.—The process *develops slowly* with insignificant or no symptoms until, after weeks or months, it has reached the size of a small or large pea. Then it presents a noticeable *swelling* (Fig. 31, upper lid), which feels hard, and is adherent to the tarsus, but not to the skin. On everting the lid its situation is shown by *discoloration of the*

FIG. 32.—Desmarres's Chalazion Forceps.

FIG. 33.—Small Scalpel.

FIG. 34.—Beer's Knife.

FIG. 35.—Chalazion Scoop.

conjunctiva and sometimes by a small mass of granulation tissue. Sometimes chalazia *disappear* spontaneously; occasionally they *suppurate*, this change being accompanied by *inflammatory symptoms*. They may be annoying merely on account of the *disfigurement*, or on account of the conjunctival *irritation* which they occasion.

Treatment.—When small, they need not be interfered with. Occasionally we can cause their disappearance by the frequent application of *ointments* of the yellow oxide of mercury, ammoniated mercury, or boric acid, associated with *massage* and *hot compresses*. When larger, we *remove them by operation*, usually through the conjunctiva, occasionally through the skin. A Knapp's entropion forceps (Fig. 43), or a Desmarres' chalazion forceps (Fig. 32) is applied with the ring blade surrounding the tumor on the conjunctival surface; the instrument is tightened so as to render the operation bloodless; the lid is everted. A vertical *incision* is made through conjunctiva and wall of the chalazion, with a small scalpel (Fig. 33), or Beer's knife (Fig. 34); the contents (Meibomian secretion, granulation tissue, and mucilaginous fluid) are removed and the walls thoroughly *scraped* with the chalazion scoop (Fig. 35).

TRICHIASIS.

Trichiasis is an *inversion* of a varying number of *lashes*, so that they rub against the cornea (Fig. 37).

Distichiasis is an infrequent condition, usually congenital, in which the lashes can be separated into *two rows*, the posterior of which is directed backward so as to rub against the eyeball (Fig. 38).

In both of these conditions the *margins of the lids have a normal position*, the displacement affecting the lashes only (Figs. 36, 37, 38).

Symptoms.—The misdirected lashes cause *mechanical irritation and injury to the cornea*, with irritation, pain, lachrymation, photophobia, opacities, and ulceration.

Etiology.—The most frequent cause is *cicatricial contraction* of the conjunctiva and tarsus in old cases of *trachoma*. Other causes are *blepharitis*, burns, *injuries* to the lids, and operations upon the lids.

Treatment.—1. *Epilation.*—When the misdirected lashes are few in number, we may epilate with the cilia forceps

FIG. 36. FIG. 37. FIG. 38. FIG. 39. FIG. 40.

FIGS. 36–40.—Section of the Upper Lid, showing Normal and Abnormal Position of Tarsus and Lashes. Fig. 36, Normal lid; Fig. 37, trichiasis; Fig. 38, distichiasis; Fig. 39, entropion; Fig. 40, ectropion.

(Fig. 41), repeating this every few weeks, since the lashes grow again.

2. *Electrolysis.*—A sponge electrode corresponding to the positive pole is applied to the temple, and a fine platinum *needle* forming the *negative pole* is introduced into the *hair-follicle*, destroying the latter; a very *weak current* is em-

FIG. 41.—Cilia Forceps.

ployed. This method results in a permanent cure, but is quite *painful;* cocaine should be injected into the lid margin.

3. *Operation.*—When a great number or all of the lashes are misdirected, operations must be performed. These

have for their object *correction of the faulty position* or *transplantation* of the lashes. Since trichiasis is frequently associated with entropion, these operations will be considered in connection with the latter disease.

ENTROPION.

A *rolling in of the margin of the lid* (and with it the lashes) (Fig. 39).

Varieties.—There are *two forms:* (1) *Cicatricial,* due to cicatricial changes in the conjunctiva and tarsus, most commonly affecting the *upper lid.* (2) *Spasmodic,* due to spasm of the palpebral portion of the orbicularis muscle, almost always occurring in the *lower lid.* The second variety is generally found in old persons (*senile entropion*) who are predisposed through relaxation of the palpebral skin and the deep position of the eyeball resulting from the absence of fat.

Symptoms.—Those due to *mechanical irritation and injury to the cornea:* irritation, pain, lachrymation, photophobia, opacities and ulceration of the cornea.

Etiology.—*Cicatricial form:* principal cause, the cicatricial changes in old cases of *trachoma,* also burns and other *injuries* to the lids, and operations upon the lids. *Spasmodic form: atrophy* or *absence of eyeball, blepharospasm, inflammatory conditions* of the lids and conjunctiva, and the prolonged wearing of a *bandage.*

Treatment.—*Non-operative* treatment may be of service in the *spasmodic variety.* If a bandage causes the entropion, we must either leave this off or apply a small roll of lint to the orbital margin beneath the bandage, exerting pressure in such a manner as to *neutralize the inversion.* In other cases we try to *remove the cause.* The lid may be kept everted for a few days by *collodion* painted on the external surface, or by *adhesive plaster* passing from the margin of the lid to the cheek. If these simple means do not an-

swer, an *operation* is indicated. In the *cicatricial form*, operation is always necessary.

Operations for Trichiasis (Distichiasis), and Entropion.—The choice of an operation (there are a *great many*) is influenced by the peculiarities existing in the individual case. The object of these operations is to remove the displaced lashes from contact with the eyeball either (1) by *changing*

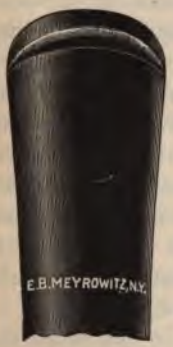


FIG. 42.—Horn Plate.

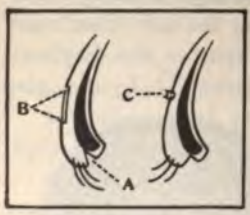
FIG. 43.—Knapp's Entropion Forceps.

the direction of the lashes from a faulty to a correct one, (2) by *transplanting* the offending zone, or (3) by *straightening the curved tarsus.*

In these operations we use either a horn plate (Fig. 42), or Knapp's entropion forceps (Fig. 43), to protect the eyeball, check hemorrhage, and give proper support to the lid. The horn plate is passed beneath the lid and pressed forward. If the lid clamp be used, its solid blade is passed beneath the lid, and the latter secured by tightening the screw of the instrument.

The Jaesche-Arlt Operation attaches the zone of hair follicles at a higher level by *shortening the skin of the lid.* The lid is split through its entire length in the intermar-

ginal space (A, Fig. 44), so that the anterior lip contains the hair follicles. A second incision, dividing the skin down to the tarsus, is made 4 mm. from and parallel to the margin of the lid. A third incision extends upwards in a curve between the two ends of the second incision (B, Fig. 44). The elliptical piece of skin bounded by the second and third incisions is dissected away without injury to the orbicularis and the margins of the defect are united by fine silk sutures (C, Fig. 45). In this manner the strip of integument containing the cilia is drawn upward and the lashes are tilted forward, away from the cornea. The area from which the skin and lashes have been displaced may be allowed to cicatrize, or may be covered by the excised strip of integument properly trimmed, which will attach itself in a few days.



FIGS. 44 and 45.—The Jaesche-Arlt Operation.

Hotz's Operation raises the zone of hair follicles by *attaching the skin to the upper border of the tarsus.* A curved incision is made through the skin of the lid following the upper border of the tarsus, from 2 mm. above one canthus to a corresponding distance above the other. While the edges of the wound are separated, a narrow strip of orbicularis along the upper border of the tarsus is exsected. The sutures, three or more in number, are then passed through the lower wound margin, upper border of tarsus, returning through the orbito-tarsal fascia, and finally through the upper wound margin (Figs. 46 and 47). This operation may be modified by the addition of an intermarginal incision, by grooving the tarsus, and by excising a horizontal strip of integument.


FIGS. 46 and 47.—Hotz's Operation.

The Streatfeild-Snellen Operation aims at straightening the inverted lid by the *removal of a wedge-shaped piece from the tarsus.* A transverse incision is made through the skin, 2 mm. above and parallel to the margin of the lid along its entire length. A strip of orbicularis is excised, thus exposing the tarsus. A wedge-shaped piece, the apex of which is directed toward the conjunctiva, is removed from the tarsus along its entire length. The cut surfaces of the tarsus are brought into contact by three sutures, provided with needles at both ends, in the following manner: One needle is passed through the tarsus above the groove; both needles are then carried down in front of the wound in the tarsus, and then between tarsus and skin, and brought out just above the free margin of the lid (Fig. 48) about 4 mm. apart. The two threads are tied upon a bead and then turned up over the forehead and secured by plaster. The cutaneous wound closes of itself.

FIG. 48.—The Streatfeild-Snellen Operation.

Operations for Spastic (Senile) Entropion include (1) *excision of a horizontal strip of skin* with the underlying orbicularis, the width being gauged so that when pinched up it shall cause the disappearance of entropion without producing ectropion; the margins of the wound are then united by silk sutures; (2) *subcutaneous sutures* (Gaillard-Arlt), which enter through the skin near the lid-margin and emerge three-quarters of an inch below; parallel threads are used, forming a loop near the border of the lid; the threads are tightened over a small roll of plaster; they are allowed to remain in place until suppuration begins in their tracks; in this manner cicatricial bands are formed; (3) *Hotz's operation;* and (4) *canthoplasty*

Canthoplasty consists in an *enlargement of the palpebral fissure* by division of the external canthus. The lids being separated and stretched at the external canthus with the

Etiology.—(1) Cicatricial contraction from wounds, operations, burns, ulcers, and caries of the orbital margin or surrounding surfaces (*cicatricial ectropion*). (2) *Chronic conjunctivitis and blepharitis* associated with considerable hypertrophy. (3) Relaxation of the skin and orbicularis in old people (*senile ectropion*), affecting only the *lower* lid. (4) Affections of the facial nerve, causing paralysis of the orbicularis (*paralytic ectropion*), affecting only the *lower* lid. (5) Spasmodic contraction of the marginal portion of the orbicularis (*spasmodic ectropion*), seen especially in children with acute conjunctivitis associated with considerable blepharospasm.

Treatment.—*Non-operative:* The *spasmodic form* is frequently relieved by a suitable retaining *bandage* applied after the lid has been properly placed. In the *paralytic form* we employ a *bandage*, at the same time attempting to *cure* the *facial paralysis.* In the *senile form* we put on a *bandage* at night, and *slit open the lower canaliculus;* we instruct the patient, when wiping away the tears, to press upward and inward and not downward and outward. In slight cases of ectropion associated with much conjunctival hypertrophy, painting the exposed surface with two-per-cent. solution of *silver nitrate* may be of service. Careful *massage* of a cicatrix may give some relief. When these simple procedures do not answer, and in *cicatricial ectropion*, we must resort to *operative intervention.*

Operations for Ectropion.—In *senile and paralytic* forms of ectropion the lid may be replaced by (1) Snellen's sutures; (2) by reduction of the length of the lid-border; and (3) by tarsorrhaphy.

Snellen's Sutures.—Two loops of thread are placed at the junction of the middle with the outer and inner third of the lid respectively, entering the everted conjunctiva at its most prominent part, brought out on the face 2 cm. below and tied over a piece of rubber tubing, so as to produce a slight amount of entropion; the threads are tightened from

day to day until they have nearly cut through, when they are removed.

Shortening the Margin of the Lid (*Adam's Operation*) is applicable when there is considerable elongation. A wedge-shaped piece is excised from the whole thickness of the lid, the base corresponding to the margin of the lid and varying from 5 to 10 mm. in width, according to the amount of shortening required; the edges are brought together by a harelip pin and the cutaneous margins by silk sutures. The piece may be excised from the centre of the lid; but, to prevent notching, it is better to operate at the external canthus.

For *cicatricial* ectropion a great many operative procedures have been advocated. An essential condition for success is the *thorough division of all cicatricial adhesions*, so that the lid assumes a natural position, the object of any operation being *to prevent recicatrization*. If the ectropion is slight and but little skin has been lost, it may be sufficient to *divide* the cicatricial bands subcutaneously, or to *cut out* the scar portion and bring the margins of the wound together by sutures. A procedure very frequently used is

The V Y Operation (*Wharton Jones*).—A V-shaped incision is made with the apex directed away from the palpebral margin, the incision including the cicatrix. The skin is freed from underlying parts, not only in the V-shaped area, but also to either side, so that the lid can be put in a natural position. The margins of the incisions are brought together by sutures in such a manner that the figure Y results.

In more *extensive cicatricial ectropion* a *plastic operation* is usually required (blepharoplasty).

Blepharoplasty consists in *covering the defect* formed by the excision of a cicatrix, new growth, or extensive ulceration, with *skin flaps with a pedicle*, taken from some adjacent part, or by means of *skin grafts*. In such operations it is customary to *close the lids temporarily by several sutures*

so as to prevent the contraction of the cicatricial tissue from undoing the result accomplished by the operation. Of the innumerable blepharoplastic operations with pedunculate skin-flaps, Knapp's, Dieffenbach's, and Fricke's methods are the ones most commonly employed.

Knapp's Method (lower lid) consists in detaching a *lateral flap* on each side of the defect in the lid, freeing it from adjacent tissue, drawing the two flaps over the defect, and uniting them by a vertical row of sutures.

Dieffenbach's Method (lower lid) makes use of an *adjacent quadrangular flap* taken from the cheek and slid inward so as to cover the defect of the lid.

Fricke's Method (upper or lower lid) consists in taking a *tongue-shaped flap* somewhat larger than and having the shape of the defect in the lid *from the temple or cheek;* the base of the flap adjoins one end of the lid wound, and is the part which becomes twisted when the flap is transplanted into the defect.

Skin-Grafting.—The defect is filled in by *one large piece* of skin or by *a number of smaller ones*, after the lid has been fastened in its proper position by temporarily suturing the two lids together. The grafts are taken from some part of the body in which the skin is *thin and delicate*, such as the inner side of the arm or thigh. The area of the graft, or grafts, must be *one-third larger* than the defect to be covered, to allow for shrinkage. The graft may consist of the *entire thickness of the skin* (Wolfe's method), or comprise only the *epidermis* (Thiersch's). The area to be covered must be clean and free from blood. When in place, the graft is covered with a layer of rubber or silk protective, and then with an antiseptic dressing. The dressing is not disturbed for three days, and the original protective layer over the graft is often left in place still longer.

Skin-grafting is now used *very extensively* and with very *good results*. If a portion of the graft sloughs, the corresponding defect can be freshened and another graft applied.

This method causes less disfigurement than when pedunculate flaps are used. *Thiersch's grafts*, being thinner and softer than Wolfe's, produce better results cosmetically, and the lid is not so heavy.

Tarsorrhaphy.—The object of this operation is to *reduce the width of the palpebral fissure* by uniting the edges of the lids at the *outer commissure*. The edges of the lids are approximated at the outer canthus to the required extent, so as to give the operator exact knowledge as to how much union is desired. A horn spatula is passed behind the outer commissure, and the desired length of the border of each lid is excised, including the hair follicles. The length of the flap varies according to the effect desired (about 3 to 6 mm.); its breadth is about 1 mm. To obtain firmer adhesion, the border of the lid, excluding the cilia, is denuded for 2 or 3 mm. beyond the point at which the first incision stops. The denuded edges are then brought together by silk sutures (Fig. 50). This operation is *indicated* in lagophthalmos, especially in Basedow's disease, in some cases of senile and paralytic ectropion, and in connection with blepharoplasty.

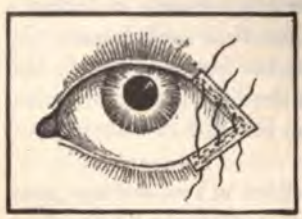


FIG. 50.—Tarsorrhaphy.

PTOSIS.

A drooping of the upper lid due to *paralysis* or *deficient development* of the *levator*. All degrees of ptosis occur. When marked, it interferes with vision by covering the pupil. Patients attempt to raise the lid by forced action of the occipito-frontalis muscle, wrinkling the skin of the forehead (Fig. 51); they favor exposure of the pupil by throwing the head backward; this *attitude is characteristic*.

Etiology.—Ptosis may be *congenital* or *acquired*. When

congenital, it is usually *bilateral*, due to *deficient development* of the levator, and often associated with other congenital defects. *Acquired* ptosis is usually *unilateral;* it is caused by *paralysis* of the branch of the *third nerve* which supplies the levator, and is usually associated with paralysis of other ocular muscles supplied by the oculomotorius. When not associated in this way, it is not infrequently the result of *cerebral disease.*

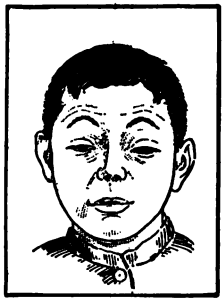


FIG. 51.—Ptosis.

Mechanical ptosis is a variety due to (1) increased weight of the lid (trachoma, tumors, etc.); (2) lack of support (atrophy of globe and after enucleation); and (3) lack of connective-tissue connection between skin and levator and upper border of orbit, in which the relaxed skin forms a fold which falls over the margin of the lid.

Treatment.—In the ordinary variety of the acquired form we seek the cause of the *paralysis of the third nerve* and treat this; *syphilitic cases* respond well to treatment. *Electricity* is used. If this treatment fails to remedy the deformity after a lengthy trial, in the *congenital* variety and in some *mechanical* cases, *operation* is indicated.

Operations for Ptosis.—Operations for ptosis *rarely give* perfectly *satisfactory results.* Their aim is either (1) to produce a *shortening of the skin* of the upper lid with or without excision of a strip of orbicularis; (2) an *elevation of the lid* by connecting it directly with the fibres of the occipito-frontalis muscle; or (3) an *advancement*, resection, or both, of the *levator muscle.*

Excision of an Elliptical Strip of Skin is a very *common* and *simple method* of operating; the effect is limited, and consequently the procedure is adapted for *slight cases* only. A fold of integument (just enough to produce the desired effect) is grasped by forceps and cut off with the subcu-

taneous tissue by means of scissors; the edges of the wound are sutured.

Excision of a Strip of Orbicularis (*Graefe's Operation*).—A horizontal incision of the skin is made across the entire lid, 5 mm. above its margin. The edges of the wound are separated and undermined and a band of orbicularis is excised. If the skin be redundant, a strip may be excised. The wound is closed by deep sutures, which include muscle and skin.

Pagenstecher's Sutures attempt to bring the occipito-frontalis to act on the lid by means of cicatricial bands. A silk thread is provided with a needle at each end. One of these needles enters the skin just above the lid margin, and after passing horizontally a short distance, passes upward beneath the skin and emerges above the eyebrow. The other needle enters the first puncture, and passing upward, emerges by the side of the first. The result is a subcutaneous loop of thread just above the lid margin. The two ends of the thread are tied over a piece of rubber tubing. The threads are allowed to remain until suppuration occurs in their tracks, and then removed, or allowed to remain and gradually drawn out above. Two or three such double sutures are used.

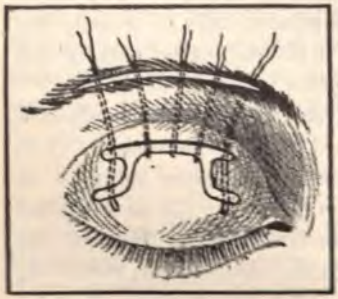


FIG. 52.—Panas' Operation for Ptosis.

Panas' Operation. — An incision (3 cm.) is made just above the eyebrow down to the periosteum, and another (2 cm.) just below the margin of the orbit, and this bridge of skin and muscle is undermined. A tongue-shaped flap including skin and muscle is separated from the lid, the free end corresponding to the lower border of the bridge of tissue at the orbital margin and the base to a line situated a short

distance above the margin of the lid (Fig. 52). This lid flap is drawn up under the bridge and stitched to the upper edge of the upper wound by three sutures. If ectropion is produced, an additional suture is applied on each side, passing through the tarso-orbital fascia only.

TUMORS OF THE LIDS.

Benign Tumors include xanthelasma, molluscum, verruca (wart), fibroma, cyst, nævus, and milium.

Xanthelasma is a flat or slightly raised, yellowish discoloration beneath the skin, found most frequently near the inner canthus in elderly women. It is due to degeneration of the muscle fibres.

Molluscum is a small, white, rounded tumor, about the size of a small pea, presenting a depression at its apex; several usually occur at the same time. They are considered contagious by some authorities. They represent a diseased condition of the sebaceous glands.

Milium is a small, yellowish-white elevation about the size of a pin's head, due to retention in a sebaceous gland.

The others resemble tumors of the same class occurring in other parts of the body. Benign tumors of the lids may be *excised*, providing too great a loss of skin is not occasioned by the operation.

Malignant Tumors.—*Sarcoma* is rare. *Carcinoma*, when it attacks the lids, usually assumes that form of *epithelioma* known as "*rodent ulcer.*" This occurs in *elderly persons*, especially at the *inner end of the lower lid margin.* It begins as a small pimple or wart, covered by a crust, soon changes to an *ulcer with indurated walls*, and spreads, if unchecked, to neighboring parts. Its growth is, however, *slow*, and many years may elapse before it assumes any considerable size.

Treatment of rodent ulcer consists in *excision;* this is always possible if done early. If advanced, we may excise

the lesion and cover the defect by *blepharoplasty*. If all the diseased tissue cannot be excised, *escharotics* (chloride of *zinc* paste or glacial *acetic acid*), or the actual *cautery* may be used.

INJURIES OF THE EYELIDS.

These are quite *common*, and include *contusions*, *wounds*, *burns*, and *insect bites*. Ecchymosis and œdema are often marked symptoms on account of the looseness of the subcutaneous connective tissue.

Ecchymosis ("*black eye*") is usually of no importance, merely causing *disfigurement*, which lasts one or two weeks. If seen immediately, *cold compresses* may be of service. After a day or two, *hot compresses* and gentle *massage* are indicated to promote absorption of the extravasated blood. Occasionally in debilitated individuals, especially if associated with abrasion, *abscess of the lid* results, and may require horizontal incision. In fracture of the base of the skull, blood travels along the floor of the orbit, and after a day or two, appears in the lower lid and bulbar conjunctiva.

Insect-bites give rise to a great deal of *swelling*, which is best controlled by *cold compresses*.

Incised wounds cause considerable gaping, if vertical, on account of division of the orbicularis, and then the scar is apt to be noticeable; if horizontal, the lips of the wound do not tend to separate, and usually heal without deformity. Incised wounds should be *cleansed* and *stitched* at once, using *fine silk* and *delicate needles*. A vertical wound of the margin must be carefully sewed so that no indentation will remain.

Lacerated and contused wounds, if extensive, should not be closed at once. After waiting a few days for necrotic particles to be cast off, the edges are brought together. Care must be taken not to produce deformity or shortening. It is often advisable to use skin grafts.

Burns should be irrigated with solution of boric acid,

dried, and covered with a *bland oil* or *ointment*. When granulating, *skin-grafts* should be supplied if the defect is extensive.

Emphysema associated with injury to the lids denotes a solution of continuity of the walls of the orbit, permitting communication with the *neighboring air cavities*. The lids will present a *soft swelling;* bubbles of air, becoming displaced in palpation, give rise to the sensation of *crepitation*. A *firm bandage* will hasten the disappearance of the air. The patient must be instructed to *avoid any straining efforts*, such as blowing the nose, which will increase the emphysema.

CHAPTER V.

DISEASES OF THE LACHRYMAL APPARATUS.

Anatomy and Physiology.—The lachrymal apparatus consists of a *secretory portion*, the lachrymal gland, and an *excretory portion*, which collects the tears and conducts them into the inferior meatus of the nose.

The lachrymal gland is a small, oblong body, placed in the upper and outer part of the orbit and divided into *two portions*. The upper part, the *larger*, about the size of a small almond, is situated in a depression in the orbital plate of the frontal bone, the lachrymal fossa, to which it is fixed by connective tissue; the lower division, the smaller, is known as the *accessory lachrymal gland*, and is placed just beneath the outer part of the conjunctiva of the fornix. In structure the lachrymal resembles the salivary glands, consisting of acini containing cuboidal cells. The *excretory ducts* of both portions of the gland, the *lachrymal ducts*, six to twelve in number, pass downward and empty into the external half of the superior fornix conjunctivæ by separate orifices.

FIG. 53.—The Excretory Portion of the Lachrymal Apparatus.

The excretory portion of the lachrymal apparatus (Fig. 53) consists of the *puncta*, the *canaliculi*, the *sac*, and the *duct*. The *puncta* are two minute openings, one of which is seen upon an elevation on each lid about 6 mm. from the inner canthus; they are the ori-

fices of the *canaliculi*. The latter extend vertically for a short distance, and then continuing at right angles, pass horizontally inward in a curved course, and empty separately or together into the lachrymal sac.

The *lachrymal sac*, situated at the inner side of the internal canthus, is the upper, dilated portion of the lachrymo-nasal duct, and is placed in a groove formed by the lachrymal bone and the nasal process of the superior maxillary bone; it measures 12 mm. in the vertical and 6 mm. in the horizontal and transverse diameters; its walls are thin; it is covered in front by the internal tarsal ligament and some fibres of the orbicularis muscle.

The *nasal duct* passes downward and slightly outward and backward in a canal formed by the superior maxillary, lachrymal, and inferior turbinated bones, and terminates below in the fore part of the *inferior meatus of the nose;* its length varies from 18 to 24 mm., and its diameter from 4 to 6 mm.; it is somewhat *contracted* where it joins the sac and again at its lower extremity. Both sac and duct are formed of fibrous and elastic tissues, and mucous membrane lined with columnar epithelium which may be ciliated; the lower part of the duct is surrounded by a dense plexus of veins.

The *lachrymal secretion* is a slightly alkaline liquid containing a comparatively large amount of sodium chloride. Ordinarily the lachrymal gland secretes just enough to *moisten the eyeball*, and this is lost by evaporation. As the result of psychical stimulation or of irritation of the eye or the nose, there is increased secretion. The conveyance of tears from the conjunctiva to the lachrymal sac is effected by the act of *winking*, the lubrication of the margins of the lids by fatty material ordinarily preventing the tears from flowing over.

Diseases of the Lachrymal Apparatus may be divided into those of the *gland* and those of the *conducting portion*.

[illegible] are very [illegible] are very

EPIPHORA.

[illegible] of tears upon the [illegible] in all affections of [illegible]. It may also be dependent [illegible] nasal ducts, inflammations, ex[illegible] and in some affections of the nose, [illegible] the terminal twigs of the trigeminus). [illegible]

[illegible] AND CANALICULI.

[illegible] punctum is directed backward and [illegible]. In *eversion of the punctum* [illegible], and away from the depression in which the tears accumulate, and the result is *epiphora*. The condition may be due to a relaxed state of the lids in *old age*, to *conjunctivitis*, *blepharitis*, and *ectropion*. It is remedied by *splitting open* the lower canaliculus with Weber's probe-pointed knife (Fig. 54), and *keeping it open* by separating the edges of the incision daily for two or three days.

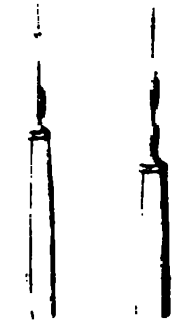


Fig. 54. Fig. 55.

Fig. 54. Weber's Probe-Pointed Canaliculus Knife.

Fig. 55. Canaliculus Irrigator.

Obstruction and Obliteration of the Puncta and Canaliculi may be *congenital*, or acquired as a result of *wounds* and *chronic inflammations* of this region. Foreign bodies (eyelash or concretion) may *obstruct* the canaliculi. Treatment consists in re-

moving foreign bodies with a delicate forceps, if possible. In the other cases *dilatation* with a fine conical sound (Fig. 55), or *splitting open* the canaliculus is indicated.

CHRONIC DACRYOCYSTITIS.

A *chronic inflammation of the lachrymal sac* usually due to an *obstruction in the nasal duct.* It is also known as *blennorrhœa or catarrh of the lachrymal sac,* and as *mucocele.*

Symptoms.—The constant symptom is *epiphora,* increased by exposure to cold, wind, dust, smoke, etc. There is fulness or *tumefaction* in the region of the lachrymal sac. By pressing upon the distended sac, a *viscid fluid* of whitish, yellowish, or greenish color (depending upon the amount of pus) escapes from the puncta; but sometimes the sac is emptied in the reverse direction, and the accumulation is pressed into the nose.

The course is *chronic* and extends over years; a long period may elapse before the patient seeks relief. After the muco-purulent material has filled the sac for a long time, there is *atrophy* of its mucous membrane and *distention* of its walls. A form of chronic conjunctivitis affecting chiefly the inner canthus (*lachrymal conjunctivitis*) and *blepharitis* are frequently present; *eczema* occurs sometimes, and there may be more or less *ectropion.* As a result of contamination by micro-organisms from the conjunctiva, a *purulent inflammation* of the lining of the sac is set up.

Etiology.—In most cases there is *stricture of the nasal duct,* the result of an *affection of the nasal cavity,* usually *rhinitis.* The duct is *predisposed* to obstruction by the existence of a plexus of veins encircling its lower end. As a result of rhinitis, there is swelling or cicatricial contraction of the mucous membrane of the duct. More rarely, pressure from tumors (polyps and hypertrophies), ulcerations, caries, and periostitis are responsible.

Treatment.—*In recent and slight cases,* we may relieve the

epiphora by *curing the nasal affection* which produces the obstruction. Locally, *stimulating and astringent remedies*, such as zinc sulphate and the ointment of the yellow oxide of mercury, may be applied to the inner part of the eyeball, followed by *gentle massage* over the sac so as to favor entrance of some of the remedy. The patient is instructed to *empty the sac* by pressure several times a day. We *wash out the sac* with *warm* and *weak solutions* of *salt*, *boric acid*, or *zinc* sulphate, using a small *syringe* with delicate nozzle (Anel's, Fig. 56). It may be necessary to dilate the lower

FIG. 56.—Anel's Lachrymal Syringe.

punctum with the fine conical sound (Fig. 55) before we can enter. If the nasal duct is pervious, the solutions will enter the nose and escape from the anterior nares when the patient inclines the head forward.

If the mild treatment just mentioned is unsuccessful, we resort to *dilatation with probes*—either Weber's conical sound (Fig. 57), or Bowman's probes (Fig. 58) which are numbered from 1 to 8, the largest (8) being about 2 mm. in thickness; they are curved before use. Probes of greater calibre (Theobald's) are sometimes used. Though the smallest probes may be passed through the natural opening, it is customary to *slit open the lower canaliculus preliminary to probing* the duct.

To Slit Open the Canaliculus.—The surgeon stands behind and supports the patient's head against his body. Weber's probe-pointed *canaliculus knife* (Fig. 54) is most frequently used. The lower lid is pulled outward by the

FIG. 57.—Weber's Conical Sound.

FIG. 58.—One of Bowman's Lachrymal Probes.

thumb of one hand, and with the other the knife is introduced vertically, until it passes the punctum, and then horizontally; its edge is upward and looks toward the eyeball so as to cut into the conjunctiva and not into

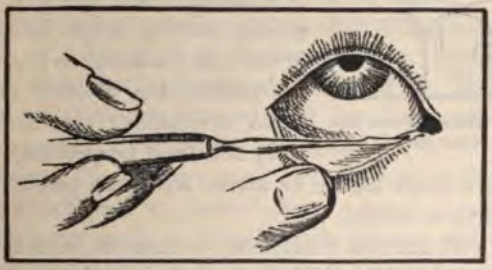


FIG. 59.—Slitting Open the Lower Canaliculus.

integument (Fig. 59). It is pushed horizontally inward until its extremity meets with the firm resistance of the inner bony wall of the sac; then the knife is raised into a vertical position.

To Pass Probes into the Nasal Duct.—Commencing with a small size, say a No. 3, we pass this horizontally inward exactly as the knife is passed, the surgeon standing be-

hind the patient. When the probe reaches the inner wall of the sac, which we can be certain of when in lifting the probe there is no wrinkling of the skin of the lower lid, it is raised so that its lower end points toward the furrow between nose and cheek. It is then pushed downward gently, until it reaches the floor of the nasal fossa (Fig. 60). If the probe does not pass readily, we must not use force, but withdraw it slightly and try again, or try a smaller or larger size. The probe is left in from fifteen to thirty minutes, and the proceeding is repeated every other day, gradually using larger probes; then the intervals between probing are increased.

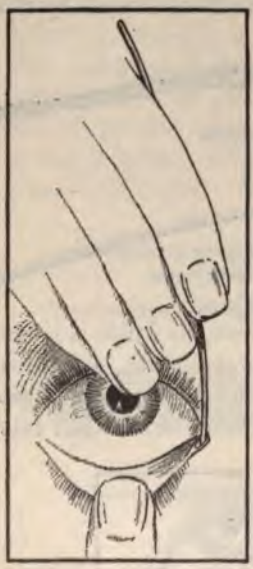


FIG. 60.—Passing a Probe into the Nasal Duct.

Sometimes the *stricture is cut*, a strong, narrow knife being passed in the same manner as a probe, and the obstruction divided in two or three directions; this is immediately followed by probing.

In some cases leaden or silver *styles* are passed and left in for days or weeks.

Even with all this treatment, permanent cures are rather the exception; there will be *temporary relief* and then the affection returns. The most favorable cases are those in which there is merely swelling of some part of the duct and the condition has not existed for too long a period. When *complete occlusion* exists, we cannot expect a cure. In such cases and in others of an *obstinate* nature, we may *slit open both the upper and lower canaliculi* and divide the tissue between these two, keeping open the cavity thus formed until there is no longer any tendency to unite. This

converts the sac into an open space which the patient can keep clean.

Incision into the Lachrymal Sac and Direct Treatment of its Walls may be practised in obstinate cases in which less radical means fail. The sac is exposed by an incision over its anterior surface, this step being facilitated by the passage of a probe through the divided canaliculus. After the rather profuse hemorrhage ceases, the lining of the sac is scraped with a sharp curette or brushed with a five-per-cent. solution of nitrate of silver or touched with the solid stick of nitrate of silver throughout its entire extent. The sac and wound are then filled with a packing of sublimate or iodoform gauze which is renewed daily. If in a few days the mucous lining of the sac appears healthy and free from purulent secretion, we allow the external wound to close.

Destruction or Extirpation of the Lachrymal Sac is resorted to in very obstinate cases, as a last resort. The sac is cut into and its cavity thoroughly exposed. Then its mucous lining is *destroyed* by galvano-cautery, chloride-of-zinc paste, or solid stick of nitrate of silver; the sac and wound are packed with sublimate or iodoform gauze and kept open until the cauterized area has been cast off; it may be necessary to repeat the cauterization.

To *extirpate the sac* we can either attempt to remove it whole, in which case we dissect down upon it, layer after layer; or we can make an incision into the sac and dissect it out from its surroundings. There is always troublesome hemorrhage. After thorough disinfection of the cavity, the external wound is closed.

These radical measures prevent conduction of the tears, but the ephipora is not apt to be troublesome and the patient is relieved from the constant danger of lachrymal abscess. Extirpation has been followed by serious complications, such as orbital cellulitis.

ACUTE DACRYOCYSTITIS.

An acute inflammation of the region of the lachrymal sac, occurring in the course of a chronic dacryocystitis, as a result of an acute exacerbation. It is also known as *Abscess of the Lachrymal Sac.*

Symptoms.—The skin over the lachrymal sac becomes *reddened* and *swollen;* this condition *extends to the lids and conjunctiva*, and is often sufficiently pronounced to lead to a suspicion of erysipelas. There are great *pain and tenderness*, some *fever* and constitutional disturbance. After two or three days a yellow discoloration appears at one point; here *pus* will be present, and should be evacuated; this will be followed by relief and a subsidence of symptoms.

The *opening* may *heal* completely, and the case again have the symptoms and slow course of chronic dacryocystitis. In other cases the opening *remains persistent* and the escaping fluid changes its character and becomes watery; this constitutes *lachrymal fistula.* As long as this remains open, the patient is safe; as soon as it closes, he is liable to have a recurrence of abscess. Sometimes merely a minute passage is left, insufficient to admit a probe, from which a drop of fluid escapes from time to time (*capillary fistula*).

Etiology.—Lachrymal abscess involves not only the sac, but the surrounding connective tissue as well. The decomposed contents of the sac find a small defect in the lining, through which *micro-organisms* reach the neighboring tissues and excite inflammation and suppuration.

The *infectious character* of the accumulation in the lachrymal sac in chronic dacryocystitis is shown, when any abrasion or ulcer of the cornea exists, by the readiness with which the wound or ulcer becomes infected. In operations upon the eye, such a condition is a very frequent cause of infection.

Treatment.—*If the case is seen early*, we try to prevent the formation of abscess, by *pressing out* the accumulation and *syringing* with *mild antiseptic solutions* (boric acid four per cent., or bichloride 1:10,000). If this cannot be done or is not effective, as is often the case, we hasten the formation of pus by *poulticing*.

As soon as fluctuation occurs, we make a *free incision* through the anterior wall of the sac, or the skin beneath which pus has formed. *After evacuation*, the incision is *kept open* by a strip of gauze which is changed daily, until all inflammatory signs have disappeared and the fluid is no longer purulent. We try to *restore permeability* of the duct, after which the fistula closes spontaneously. If this does not happen after the duct becomes pervious, we freshen and unite the edges of the opening, or cauterize them with silver nitrate or the actual cautery, or scrape out the track with a sharp spoon. In some cases it may be advisable to *destroy or extirpate the sac*, but never until all acute symptoms have subsided.

CHAPTER VI.

DISEASES OF THE ORBIT.

ANATOMY.—[illegible] other [illegible] [illegible] portion of the orbit presents three openings [illegible] adjacent cavities: 1. the optic foramen, transmitting the optic nerve and the ophthalmic artery; (2) the sphenoidal fissure, transmitting the ophthalmic vein, the nerves of the ocular muscles, and the first branch of the trigeminus; (3) the spheno-maxillary fissure, transmitting branches of the second division of the trigeminus.

Besides communicating with the cavity of the skull by means of the openings at the apex, the orbit is *surrounded by a number of other cavities*. These are the nasal fossæ and accessory cavities—the ethmoidal and sphenoidal sinuses, the frontal sinus, and the antrum of Highmore; these relations are important.

The *contents* of the orbit consist of the eyeball and optic nerve, the ocular muscles, the lachrymal gland, blood-vessels, and nerves; the spaces between these are filled with fat and fasciæ.

The *eyeball* is composed of the segments of two spheres;

the anterior (cornea), about 12 mm. in diameter, is the smaller and more prominent; the larger, posterior, corresponds to the sclera. The eyeball measures about an inch in diameter (24.5 mm. from side to side, 24 mm. from before backward, and 23.5 mm. from above downward).

The orbital fascia is extensive and presents numerous subdivisions. It serves as *periosteum* to the walls of the orbit (periorbita). A portion closes in the opening of the orbit forming an anterior wall, and extending from the margin of the orbit to both tarsi, and to the external and internal tarsal ligaments, thus constituting the *septum orbitale*. Prolongations of the orbital fasciæ surround the muscles and connect them with one another, the lids, and the margins of the orbit.

In addition, a layer of fascia surrounds the globe from the cornea to the posterior part, separating the organ from the orbital fat and forming an articular socket, which permits free movement of the eyeball in every direction. This investment is known as *Tenon's capsule*. The contiguous surfaces of the sclera and of Tenon's capsule are smooth and lined with endothelium. In this manner a lymph space is formed known as Tenon's space, which is continuous posteriorly with the supravaginal space surrounding the external sheath of the optic nerve. Where the tendons of the ocular muscles pierce Tenon's capsule, the latter is reflected upon them, becoming continuous with their fasciæ.

The *arterial supply* of the orbit is derived from the *ophthalmic*. The *veins* empty into the *ophthalmic* veins, which pass through the sphenoidal fissure to the *cavernous sinus*. The *nerves* of the orbit are motor and sensory; the motor nerves, the *third*, *fourth*, and *sixth*, supply the ocular muscles; the sensory nerves are the first and second branches of the *trigeminus*. The *ciliary ganglion* lies to the outer side of the optic nerve; it receives motor fibres from the third, sensory fibres from the fifth, and sympathetic filaments from the carotid plexus; it gives off the

short ciliary nerves which enter the eye at its posterior par
The orbit contains no lymph-vessels or lymphatic gland

Affections of the Orbit frequently present a characterist
symptom, exophthalmos.

Exophthalmos (*proptosis*) is a *protrusion of the eyeba*
from the orbit. It is *caused* by *inflammations* and *tumo*
of the orbit, *dilatation* of adjoining cavities, Basedow'
disease, and in some cases by *paralysis* of the recti muscle
and tenotomies of these muscles. When of high degree
it may cause *interference with* the *mobility* of the eye, *im*
perfect closure of the lids (lagophthalmos), with resultin
keratitis from exposure, *ectropion* of the lower lid, *diplopi*
(if lateral displacement is added), and interference wit
vision from inflammation and atrophy of the optic nerve

Enophthalmos is the *recession* of the eyeball into th
orbit. With the exception of the cases seen in the *aged*
and in extreme emaciation due to the decrease of orbital fat
it is *rare*. Other causes are paralysis of the sympathetic
injuries to the orbit causing cicatricial contraction, an
fracture of the orbital wall

ORBITAL PERIOSTITIS.

An inflammation of the orbital periosteum, either *acute o*
chronic in its course, and either *limited* to a portion of th
margin of the orbit or *spreading* more deeply.

The *products of inflammation* often consist merely of
thickening of the membrane; sometimes there is a *depos*
of bone or gumma (syphilis); there may be the formatio
of an *abscess*, with or without *caries or necrosis* of a part o
the wall of the orbit

Symptoms.—These depend upon whether the affectio
runs an acute or a chronic course, the part of the orbit in
volved, and the nature of the products of inflammation

The *most common* variety is that attacking the *margin o*
the orbit. In such a case there may be no other symptom

than *pain, tenderness* on pressure at the orbital margin, hard immovable *swelling* in this situation, and some *swelling of the lids and conjunctiva* Such a case frequently results in complete *absorption* of the products of inflammation; less commonly, periosteal thickening or bony deposit remains. If, on the other hand, there is pus, a periosteal *abscess* is developed at the margin of the orbit, which perforates through the skin, leaving a *fistula* through which the probe detects either bare or necrosed bone. Such a fistula remains open for months until all the dead bone has been extruded, and after it heals there is a depressed *scar* and sometimes ectropion and lagophthalmos.

If the periostitis is *situated more posteriorly*, there will be *more pain*, and this will be of a *deep-seated* character. Such cases may result in absorption of the products of inflammation, or in periosteal thickening or bony deposit. But if such a deep-seated process goes on to the formation of an *abscess*, it becomes much more serious and presents the *symptoms of orbital cellulitis*, from which it frequently cannot be differentiated. The pus finds its way to the surface, but this may take some time Cases of this sort, especially if they involve the roof, may be dangerous to life through extension to the cranial cavity and the occurrence of meningitis or cerebral abscess.

Etiology.—*Injuries*, especially infected wounds; *tuberculous* diathesis (in children); *syphilis* (in adults); *rheumatic* diathesis; *extension* from neighboring cavities or bones, and *cold*. Rheumatic and syphilitic cases usually run a chronic course and produce periosteal thickening without any tendency to suppuration.

Treatment.—That of syphilis, rheumatism, or tuberculous diathesis. *Locally*, moist, *warm compresses*. *Incision* as soon as there are any signs of suppuration. Early incision by means of a narrow knife is indicated as soon as we suspect the existence of pus, so as to prevent the extension of suppuration to the brain. The opening is drained by

means of a strip of iodoform gauze, until pus no longer escapes. Caries and necrosis may require subsequent operative intervention.

ORBITAL CELLULITIS.

Orbital Cellulitis or Abscess is an *inflammation of the cellular tissue* of the orbit, terminating in *suppuration*. It runs an *acute course*, accompanied by marked *constitutional symptoms*.

Symptoms.—Great *swelling* of the lids, *chemosis*, *exophthalmos*, *impairment of mobility* of eyeball, *violent pain* in the orbit and side of head increased by pressure against eyeball; these local signs are accompanied by *marked constitutional symptoms*, with high fever; cerebral symptoms may be added. *Vision* may not be affected, or it may be reduced or abolished owing to the occurrence of optic neuritis. After these symptoms have lasted about a week, *pus appears* at a certain part of the skin of the lids and perforates, or it may empty into the fornix. After the evacuation of pus, the *symptoms* rapidly *subside* and the opening heals.

Complications.—Optic neuritis; less frequently, thrombosis of the retinal vessels; occasionally panophthalmitis. Extension of the process to the brain may be fatal.

Etiology.—1. *Injuries* and operations followed by *infection*. 2. *Extension* of inflammation from neighboring parts. 3. Facial *erysipelas*. 4. *Metastasis* (pyæmia, puerperal septicæmia, etc.). 5. *Cold* (idiopathic).

Treatment.—*Hot fomentations*. Early and *deep incision* in the spot where we suspect the abscess to be situated, either through the conjunctiva or through the skin. Even when we do not strike pus, we relieve tension and prepare a route for the subsequent evacuation.

Tenonitis is a *rare* affection, consisting of *serous inflammation of Tenon's capsule*, and resulting in cure in a few

weeks. Its *symptoms* are moderate swelling of the upper lid, chemosis, slight exophthalmos, and limitation of movements of the eye, some pain on motion of eyeball It may *follow* a tenotomy of one of the recti muscles, exposure to cold, be idiopathic, or due to rheumatism *Treatment* consists of cold or warm fomentations, and the treatment of the rheumatism if present.

Pulsating Exophthalmos.—This term comprises a number of conditions which present the following *symptoms:* Exophthalmos, pulsation of the eyeball and surrounding parts, bruit heard over the eye and forehead, noises in the head, pain, and marked distention of the blood-vessels of the retina, conjunctiva, and lids. Compression of the carotid of the same side causes a diminution or disappearance of the pulsation and bruit. It is most frequently produced by an *arterio-venous aneurism* due to rupture of the carotid into the cavernous sinus, generally caused by *traumatism.* The condition may be fatal from hemorrhage. *Treatment* consists in digital or instrumental compression of the common carotid; if this does not succeed, ligation of this vessel; most cases are cured in this manner.

Tumors of the Orbit are of *infrequent* occurrence. The *symptoms* will depend upon the size, position, and nature of the tumor. Exophthalmos is usually present. The direction of the protrusion and the impairment of motion of the eyeball will be determined by the exact situation of the tumor. Pressure upon the optic nerve may cause optic neuritis and atrophy When located forward or after it has reached a certain size, the tumor may be felt by the tip of the finger passed between the margin of the orbit and the eyeball. *Benign tumors* usually grow slowly and frequently give few symptoms; *malignant tumors* increase in size very rapidly and cause much pain *Benign* tumors of the orbit include dermoid cyst, aneurism, angioma, pulsating exophthalmos, meningocele, osteoma, and distention of

neighboring cavities. *Malignant* tumors are sarcoma and carcinoma.

Distention of Cavities Adjoining the Orbit.—The cavities adjoining the orbit (*frontal* sinus, *maxillary* antrum, *ethmoidal* cells, and *sphenoidal* sinus) are lined by an extension of the lining of the nose with which they are connected. As a result of catarrhal inflammation or from other causes, these communications may become narrowed or obliterated. The lining membrane of these accessory sinuses continuing to secrete, there soon follows distention with mucous fluid (*dropsy*), or with purulent fluid (*empyema*). The orbit will be encroached upon and the eyeball displaced. The process may also result from *disease* of the lining membrane.

The frontal sinus is affected more frequently than any of the others. A *bulging* is noticed at the upper and inner part of the orbit, with or without pain. The thin layer of bone is absorbed and an *elastic swelling* appears. *Treatment* consists in making an *opening* into the frontal sinus through the integument and bone, washing out and *draining* for some time. Or we may make an opening by way of the nasal fossa and drain in this manner.

Injuries of the Orbit include contusions, incised and penetrating wounds, foreign bodies, and fracture of the orbital wall. A prominent sign is hemorrhage into the orbit, causing *exophthalmos* and its symptoms, and by pressure, atrophy of the optic nerve. If the wound becomes infected, orbital abscess will develop. In penetrating wounds, foreign bodies, and fractures, the optic nerve may be injured, and as a consequence there will be atrophy. In fractures, emphysema is a common sign. *Fractures* not only affect the orbital margin but occur more deeply, and then may involve the wall of the optic canal and injure the optic nerve; such deep fractures are produced by direct violence, and also indirectly by contre-coup. *Treatment consists* in cleansing and disinfecting the wounds,

and endeavoring to extract foreign bodies. During the time that secretions are escaping from the wound, the latter should be kept open.

Congenital Anomalies of the Eyeball are *rare*: they are usually bilateral. *Anophthalmos* is a small solid or cystic mass occupying the place of the eyeball. *Microphthalmos* consists of an eyeball of diminished size in all diameters. *Macrophthalmos (congenital glaucoma)* is an increase in size of the eyeball with symptoms of glaucoma, usually resulting in blindness (p. 190).

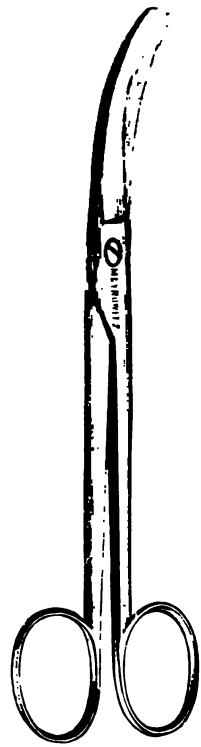


FIG. 61.—Enucleation Scissors.

OPERATIONS UPON THE EYEBALL.

Enucleation of the Eyeball.—*The instruments required* are: (1) eye speculum (Fig. 220); (2) fixation forceps (Fig. 218); (3) toothed forceps (Fig. 219); (4) curved, blunt-pointed strabismus scissors (Fig. 223); (5) two squint hooks (Fig. 222); (6) strong, curved enucleation scissors (Fig. 61); (7) needle holder (Fig. 224); (8) fine, curved needle, and thin black silk.

Operation.—A general anæsthetic is generally given. After introduction of the speculum, the conjunctiva is divided all around the cornea, as close to its border as possible, and dissected back as far as the insertions of the recti muscles. A squint hook is passed beneath the tendon of the internal rectus, and the latter is divided with the strabismus scissors close to its insertion; then the other straight muscles are cut in the same way, together with the sub-

conjunctival connective tissue for some distance beyond the equator. The points of the scissors must always be directed toward the eyeball and the latter stripped as clean as possible to avoid any unnecessary removal of orbital tissue. Instead of commencing with a circumcorneal division of the conjunctiva, we may begin with a tenotomy of the internal rectus and then divide the conjunctiva as we pass from tendon to tendon. The hook is passed around the globe to make sure that the attachments of the muscles have been completely divided. The eyeball is then dislocated forward by pressing the speculum backward, and thus the optic nerve is put on the stretch. A pair of enucleation scissors (Fig. 61), closed, are passed between sclera and conjunctiva, feeling for the optic nerve; they are withdrawn, slightly opened, and the nerve is divided close to the sclera. The eyeball is held between the thumb and index finger of the left hand, and the oblique muscles and other unsevered attachments are divided. The orbit is plugged for a few minutes to control hemorrhage, and the conjunctiva is usually closed with a single suture, which is passed through its edge at intervals and tied like the string of a pouch. The eye is bandaged and the patient kept in bed for a day.

If, during the operation, the globe ruptures, the perforation should be closed with a suture to preserve the form of the eyeball; a collapsed globe makes the operation more difficult. Troublesome hemorrhage may occur; it can be controlled by hot water or by a firm bandage. When an eyeball containing a malignant growth is enucleated, as much of the optic nerve as possible should be removed. In rare cases infection of the wound leads to abscess, thrombosis, and even fatal meningitis. The tendency to meningitis is somewhat increased in enucleation of suppurating eyeballs; hence many oculists consider panophthalmitis a contraindication to enucleation, and postpone operation until after the suppurative process has ceased.

The *Indications for Enucleation* are: (1) Injuries of the ciliary region, when the eye is completely blind, or the traumatism so extensive that the form of the eyeball cannot be preserved; (2) traumatic irido-cyclitis, to prevent or cure sympathetic ophthalmia; (3) severe pain in a blind eye; (4) irido-cyclitis, phthisis bulbi, and glaucoma, when accompanied by severe pain or inflammatory symptoms, and when the eye is blind or is certain to become so; (5) malignant tumors, either intraocular or epiocular, if they cannot be removed with retention of the eyeball; (6) anterior staphyloma, if the eye is blind, troublesome, and disfiguring; (7) panophthalmitis, after the suppurative stage is passed; (8) foreign bodies in the eye when they cannot be removed and cause irritation, or the eye is blind.

Evisceration of the Eyeball.—In this operation the cornea and entire contents of the eyeball are removed, the sclera alone remaining.

The instruments required are: (1) eye speculum (Fig. 220); (2) fixation forceps (Fig. 218); (3) curved strabismus scissors (Fig. 223); (4) Graefe knife (Fig. 103) or Beer knife (Fig. 34); (5) sharp spoon; (6) needle holder (Fig. 224); (7) small curved needles, catgut and silk sutures.

Operation.—After insertion of the speculum, the eye is transfixed just behind the cornea with a Graefe or Beer knife, which is made to cut its way out at the upper sclero-corneal junction; the other half of the cornea is removed with the scissors. The contents of the eyeball are then removed thoroughly with a sharp spoon, care being taken that nothing but sclera is left. The cavity is irrigated and allowed to fill with blood, or else dried. The scleral edges are brought together in a vertical line with catgut sutures, and the conjunctiva is united horizontally with silk sutures.

Recovery is less rapid than after enucleation, and the pain and reaction are greater; the support for an artificial eye is usually better. The operation may be substituted

for enucleation in all cases excepting malignant tumors, foreign bodies, and sympathetic ophthalmia. Fatal cases occur in rare instances, with about the same degree of frequency as after enucleation.

Evisceration with Insertion of an Artificial Vitreous (Mules' Operation).—Following evisceration, after the scleral cavity has been cleansed and hemorrhage checked, a hollow sphere of glass or silver (or some other substance) is introduced. This ball must not be too large; its introduction is facilitated by slitting the sclera and by the use

FIG. 62.—Artificial Eyes.

of a special inserting instrument. The wound is then closed and dressed as after the ordinary operation of evisceration. There is considerable reaction after this operation, and the patient is confined to his room for a week. The stump is undoubtedly superior to that furnished by any other method, but it frequently happens that the ball is extruded.

Artificial Eyes (Fig. 62) are worn after enucleation and evisceration, for cosmetic purposes and properly to fill out the cavity left between the lids. They can be worn as soon as the socket is free from inflammation, usually after several weeks. The artificial eye should be washed frequently, and must be removed every night. After a year its surfaces and edges become roughened, and it must be replaced by a new one.

CHAPTER VII.

DISEASES OF THE CONJUNCTIVA.

Anatomy.—The conjunctiva is a thin layer of mucous membrane which lines the eyelids and is reflected on to the eyeball, forming a sac, the *conjunctival sac.* We distinguish three divisions: (1) The *palpebral* conjunctiva, covering the under surface of the lids; (2) the *ocular* conjunctiva, coating the anterior portion of the eyeball; and (3) the *fornix*, the transition portion, forming a fold between lid and globe. The conjunctiva differs somewhat in structure in each of these portions.

The palpebral conjunctiva is thicker than the other portions. In the greater part of its extent it is closely adherent to the subjacent tarsus, allowing the Meibomian glands to be seen through it. Its surface is smooth, but presents a number of minute projections, or *papillæ.* It is covered with cylindrical epithelium. Its stroma is of an *adenoid* character, containing a large number of lymph corpuscles, which may in some cases be collected into small rounded masses (*lymphoid follicles*). It is a disputed question, however, whether these are normal or are the result of pathological processes. Numerous *mucous glands* are also found.

The conjunctiva of the fornix is similar in structure to that of the lids. It constitutes a *very loose fold*, insuring great freedom of movement to the eyeball. It is richly supplied with blood-vessels. This and its lax condition explain its liability to marked swelling in inflammations of

the conjunctiva. It has opening into it the lachrymal ducts and numerous mucous glands.

The bulbar portion of the conjunctiva, thin and transparent, covers the anterior surface of the eyeball, being loosely attached to the sclera by connective tissue (*episcleral tissue*), with the exception of the margin representing the boundary between cornea and sclera (*limbus*), where it is firmly adherent. In structure it resembles the rest of the conjunctiva but contains no glands. It is covered with laminated pavement epithelium which is continued uninterruptedly over the cornea, and constitutes its outer layer. Near the inner canthus it forms a crescentic fold (*plica semilunaris*), the rudiment of the nictitating membrane or third eyelid of the lower animals.

The vascular supply of the conjunctiva is derived from the blood-vessels of the fornix—the *posterior conjunctival* (derived from the palpebral) and from the *anterior ciliary*. The latter pass forward along the recti muscles and pierce the sclera near the limbus to reach the interior of the eye, giving off one set of branches which form *vascular loops* surrounding the cornea and supplying it with nourishment, and another set (*anterior conjunctival*), which pass backward in the conjunctiva and anastomose with the posterior conjunctival. This arrangement, together with the posterior ciliary arteries and the retinal system of vessels, constitutes the entire vascular system of the eye. Thus the bulbar conjunctiva presents *two vascular systems*—the posterior conjunctival and the anterior ciliary. The nature of the injection in any given case is of some value in locating the seat of the congestion.

The *nerves* of the conjunctiva, branches of the *fifth*, terminate in end-bulbs, and are especially abundant in the palpebral portion. *Lymphatic vessels* are found in considerable numbers in the conjunctiva, forming a superficial and a deep layer.

CONJUNCTIVAL AND CILIARY INJECTION.

The differences between conjunctival (Fig. 63) and ciliary or circumcorneal injection (Fig. 64) are as follows:

Conjunctival Injection.	*Ciliary Injection.*
1. Derived from posterior conjunctival vessels.	1. Derived from anterior ciliary vessels.
2. Accompanies diseases of the conjunctiva.	2. Accompanies diseases of the cornea, iris, and ciliary body.
3. More or less muco-purulent or purulent discharge.	3. Often lachrymation, but no conjunctival discharge.
4. Most marked in fornix conjunctivæ.	4. Most marked immediately around the cornea; hence called "circumcorneal."
5. Fades as we approach the cornea.	5. Fades toward the fornix.
6. Bright, brick-red color.	6. Pink or lilac color.
7. Composed of a network of coarse, tortuous vessels, anastomosing freely, and placed superficially, so that the meshes are easily recognized.	7. Composed of small, straight vessels, placed deeply, so that the individual vessels cannot be recognized easily, but are seen indistinctly as fine, straight lines radiating from the cornea.
8. Can be moved with the conjunctiva by pressure on lower lid.	8. Cannot be displaced by movement of the conjunctiva.

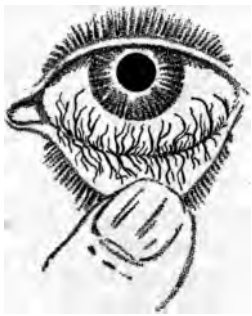


FIG. 63.—Conjunctival Injection.

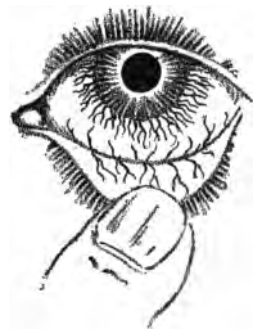


FIG. 64.—Circumcorneal (Ciliary) Injection.

In severe forms of diseases of the anterior part of the eye these two types of congestion are often found associated, as we would expect when we remember that the two systems of vessels anastomose freely.

When very pronounced, particularly when there is much venous congestion, ciliary injection assumes a *violet* color. A form of injection of this sort involves the *episcleral* tissue between the equator of the eyeball and the cornea, presenting a deeply placed, violet-colored patch seen in scleritis and glaucoma.

CONJUNCTIVITIS.

Inflammations of the conjunctiva are known as *conjunctivitis*, or *ophthalmia*.

The *varieties* are:

1. Catarrhal; (a) acute, (b) chronic, (c) follicular.
2. Purulent; (a) ophthalmia neonatorum, (b) gonorrhœal.
3. Membranous; (a) non-diphtheritic or croupous, (b) diphtheritic.
4. Granular or trachoma.
5. Phlyctenular.

ACUTE CATARRHAL CONJUNCTIVITIS.

An acute catarrhal inflammation of the conjunctiva accompanied by *mucoid or muco-purulent discharge*. It is also known as *acute muco-purulent* and *acute simple conjunctivitis*.

Objective Symptoms.—The palpebral *conjunctiva* and that of the fornix are of a brilliant *red color and swollen*. There is slight congestion of the bulbar conjunctiva; but in severe cases this may become marked, and there may be added œdema of the bulbar conjunctiva (chemosis), small conjunctival hemorrhages, and œdema of the lids. The *secretion, increased* in amount and *altered* in character, varies

according to the severity. In mild cases, it is *mucoid;* in severer forms, it is *muco-purulent;* in very marked examples, the amount of pus may be so considerable that for a day or two we may be in doubt whether the disease is not the beginning of a purulent inflammation. The secretion accumulates during the night and dries upon the edges of the lids during sleep.

Subjective Symptoms.—*Itching and smarting sensations* referrred to the lids, which *feel hot, heavy,* and as though sand or a foreign body were underneath. There is more or less *photophobia.* There may be some blurring of sight when the altered secretion lies upon the cornea. The symptoms are usually *worse toward evening;* they vary in severity with the degree of inflammation. The affection may be limited to one eye, but usually *both eyes* are implicated, either from the start or after two or three days.

Course.—Most patients *get well in a few days,* or in a week or two, even without treatment. Sometimes the acute symptoms subside and a *chronic* catarrhal conjunctivitis remains. *Blepharitis* may be present. In severe cases small, grayish infiltrations may form at the corneal-margin. The coalescence of a number of these may cause a marginal ulcer, which is usually unimportant, superficial, and heals readily, but occasionally becomes deep and serious. Rarely iritis occurs as a complication.

Etiology.—The disease occurs at *all ages* and at all times during the year, but is most common in the *spring and fall.* The *causes* may be divided into: 1. *Mechanical*—foreign bodies, exposure to wind, dust, smoke, etc. 2. *Epidemic*—in spring and fall and depending upon some atmospheric condition (the presence of certain micro-organisms). 3. *Infection*—through contact with fingers, towels, handkerchiefs, etc., of patients suffering from the disease. The discharge is *contagious,* especially when free and containing much pus; hence the affection often presents a number of examples in the same household or school. 4. *Exanthem-*

ata, accompanying or following measles, scarlatina, and small-pox. 5. *Associated* with coryza, rose cold, hay fever, and grippe.

Clinical Varieties.—Certain forms of this disease are distinguished by qualifying adjectives, indicating the etiology.

Traumatic Conjunctivitis is the name often given to acute catarrhal conjunctivitis when excited by the presence of a *foreign body* or by *traumatism*. Under this head are included the forms of conjunctivitis due to *intense light*, for example the electric arc light or that used in electric welding (*ophthalmia electrica*), and that produced by reflection from snow (*snow blindness*). In such cases there are symptoms of conjunctivitis, and, in addition, marked photophobia, lachrymation, intense smarting of the lids, contraction of the pupil, and sometimes œdema of the lids and superficial ulceration of the cornea.

Exanthematous Conjunctivitis, when associated with the exanthemata; most commonly seen in *measles*.

Acute Epidemic Conjunctivitis, popularly known as "*pink-eye*," is a form of acute catarrhal conjunctivitis occurring most frequently in the *spring* and *fall*, in which the symptoms are apt to be *marked* and the discharge is *profuse*. The contagious element is the Koch-Weeks bacillus.

Other Clinical Varieties of acute catarrhal conjunctivitis have been classified according to the *micro-organism* which seems responsible for the inflammation. One form is caused by the diplo-bacillus of Morax-Axenfeld, another by the pneumococcus, and a third by the streptococcus.

Follicular Conjunctivitis is considered by some authorities as a variety of *acute catarrhal conjunctivitis*, by others as a form or stage of *trachoma*. It will be described separately.

Treatment.—Though the disease tends to get well without interference, treatment reduces the duration and prevents the change into chronic conjunctivitis. *Iced compresses* should be applied for from fifteen minutes to an

hour, three times a day. The conjunctival sac should be *irrigated* several times a day with *salt* solution (3 i. to Oi.), or saturated solution of *boric acid.* A *bland ointment* (vaseline or boric-acid ointment) is applied to the edges of the lids at night, to prevent them from becoming glued together during sleep. The patient is cautioned concerning the *contagiousness* of the discharge. We should, if possible, remove the original cause.

If the disease shows a tendency to become *obstinate or chronic, weak astringent solutions* are indicated (zinc, alum, potassium chlorate, silver nitrate), accompanied with an occasional application of one-per-cent. silver-nitrate solution or the alum stick to the everted lids.

CHRONIC CATARRHAL CONJUNCTIVITIS.

A chronic catarrhal inflammation of the conjunctiva, presenting similar symptoms to those found in the acute form, but associated with only *slight changes* in the *quantity* and *quality* of the *secretion.* It is also known as *chronic simple conjunctivitis.*

Objective Symptoms.—The *conjunctiva* of the lids is *reddened* and smooth; in old cases it may be *hypertrophied* and *velvety.* The *secretion* is usually but *slightly altered,* and there is very *little increase;* there may be enough to make the eyelids stick together in the morning or to present some dried secretion at the inner canthus. There is apt to be some *excoriation* at the outer angle (*angular catarrh*). In some cases there appears to be less than the normal amount of secretion (*dry catarrh*).

Subjective Symptoms are the *same in kind as in the acute form:* Itching, burning, dryness, feeling of sand or foreign body, heavy feeling in lids, some sensitiveness to light, and the eyes tire easily. These symptoms are *worse at night.*

Course.—The disease is probably the *most common* of

Objective Symptoms.—[illegible] *found in* [illegible] the conjunctiva of the *lower lid* presents a variable number of small, pale, round *granules*, about the size of the head of a pin: if many are present, they may be arranged in rows: they are most abundant in *or near the fornix*. Occasionally some are found on the upper lid. These follicles consist of small

masses of *adenoid tissue*, in which respect the pathology resembles that of trachoma. On this account, and also because the secretion may excite trachoma in another eye and the disease may terminate in granular conjunctivitis, some authorities consider follicular catarrh to be a stage of trachoma.

Subjective Symptoms are identical with *those of catarrhal conjunctivitis.* In many cases patients do not complain of any symptoms and the existence of the granulations is discovered accidentally.

Course.—The disease may be either *acute* or *chronic.* In either case the course is *obstinate;* in chronic cases the follicles may persist for months and even years. It is sometimes difficult, especially in acute cases, to differentiate between follicular catarrh and granular conjunctivitis, and we may have to await the results of several weeks' treatment in order to decide definitely. The *follicles*, in this disease, *disappear after a time*, leaving the conjunctiva in a natural condition, and they affect principally the lower lid; in trachoma, on the other hand, there are permanent changes in the conjunctiva, and when the granulations are confined to one lid, it is the upper which is involved.

Etiology.—It occurs most frequently in *children* and in young persons; it is often found in *schools and asylums.* The exact cause is not definitely known. *Contagion* seems responsible in some cases. *Poor hygienic surroundings*, especially in-door life, seem to predispose. The various causes of catarrhal conjunctivitis act as exciting factors.

Treatment.—The *same* as that given for acute and chronic *catarrhal conjunctivitis.* It is of special importance to correct any interference with the general health and to place such children under the *best hygienic surroundings. Locally*, the *ointment of the yellow oxide of mercury*, applied within the conjunctival sac, is a favorite remedy. The occasional use of one-per-cent. solution of *nitrate of silver* may be of service. When the patient no longer complains

of any symptoms and the follicles persist, they may be allowed to remain and treatment discontinued.

PURULENT CONJUNCTIVITIS.

An *acute* purulent inflammation due to *contagion from gonorrhœal virus.* The contagious elements are the *gonococci* (Neisser); they occur in gonorrhœal secretion, are found in the pus cells and conjunctival epithelium, and are arranged in pairs (diplococci) and generally in colonies.

Clinical Varieties: (1) *Adult* Purulent Conjunctivitis or Gonorrhœal Ophthalmia or Conjunctivitis. (2) *Infantile* Purulent Conjunctivitis or Ophthalmia Neonatorum (occurring in the *new-born*).

ADULT PURULENT CONJUNCTIVITIS OR GONORRHŒAL OPHTHALMIA.

Symptoms.—*First Stage, Infiltration.*—After a period of incubation varying from a few hours to two or three days (short in severe cases), there occur *great swelling and redness of the lids,* so that the latter cannot be opened voluntarily and can be separated only with difficulty. The *conjunctiva* of the lids and fornix is *intensely swollen* and *reddened* and is uneven; there is *chemosis* (œdema of the ocular conjunctiva, causing it to swell up around the cornea). The secretion is at first *serous,* somewhat colored with blood, and containing a little pus. The eye is *tender* to touch. There are some *constitutional disturbance,* slight fever, and some swelling of the preauricular gland. This stage lasts about *two days* and is followed by the

Second Stage, The Stage of Purulent Discharge.—The swelling of the lids and conjunctiva and the chemosis diminish and the eye becomes less tender. A very *profuse, purulent discharge* appears and escapes continually from between the lids. This condition continues for *two or three weeks, all* symptoms gradually diminishing

Third Stage, Convalescence or Papillary Swelling.—The eye may return to a *normal* condition in two or three weeks. More frequently, however, there is a stage of *papillary swelling*, a chronic inflammation of the lids; the palpebral and retrotarsal conjunctiva remaining thickened and red and presenting, especially over the tarsus, an *uneven granular or velvety appearance*, with hyperæmia of the ocular conjunctiva.

Course.—The disease occurs in *various degrees of severity.* Cases in which there is slight infection, or in which the disease is acquired from a chronic gonorrhœa (gleet) are the mildest. The very intense cases have probably been acquired through contagion from the secretion of a very virulent gonorrhœa, and especially from contamination during the early stages. In these very severe forms there may be a deposit of croupous membrane upon the conjunctiva.

Etiology.—The disease is always acquired through *infection from gonorrhœal secretion*, either *directly*, the fingers of the patient transferring the virus from the genitals, or *indirectly* by means of contaminated towels, etc.

Complications.—A very frequent and important complication is *corneal ulceration.* This begins with a circumscribed grayish *infiltration*, becoming yellow and breaking down, so that *ulcers* are formed. The ulcers vary in situation, size, and course. They may be central or marginal; the latter may be confluent, so as to form an annular ulcer. The ulcers may *perforate* and this be followed by cicatrization with or without incarceration of the iris, staphyloma, and other *sequelæ of corneal ulceration.* Panophthalmitis may result. Severe and early involvement of the cornea is most common in intense attacks; in such cases, serious and permanent *damage to the eye* is very common.

Prognosis depends upon the *severity* of the case, and upon the *behavior of the cornea.* It is always grave.

Treatment.—*Prophylactic:* Great precautions must be observed to *prevent infection* of the eyes of the physician, nurse, and attendants through spurting of the discharge during examination or treatment; *protecting glasses* should be worn whenever exposed to this risk. Contaminated *fingers* must be carefully *disinfected. Materials* which have been used for cleansing the eye must be *burned.*

The *non-affected eye* should be *protected* from infection by the application of *Buller's shield* (Fig. 65). This consists of a watch glass, securely held in place by adhesive plaster applied to the side of the nose, the cheek, and forehead. The junction of skin and plaster is sealed by a layer of collodion. The centre of the glass is left uncovered by plaster to permit inspection of the eye, and a small part of the outer margin of the watch glass is usually left free in order to allow air to enter and contribute to the comfort of the shielded eye.

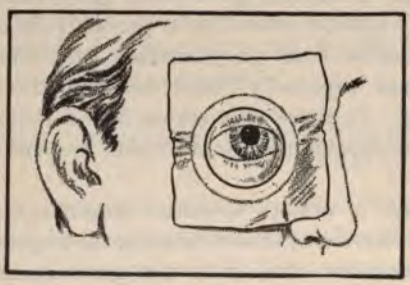


FIG. 65.—Buller's Shield.

Treatment of the First Stage: Iced compresses are used *continuously*, day and night. The eye must be carefully *cleansed* and the *secretion removed* as rapidly as it forms. When very abundant, this will be necessary *every quarter or half an hour.* For this purpose a *saturated solution of boric acid* is most frequently employed, being allowed to trickle in between the lids from a piece of absorbent cotton dripping with the solution; then the secretion which has been washed out is gently *wiped off* the margins of the lids.

The iced compresses may be used continuously at first. *But when the* tense, reddened, and swollen condition of the

lids becomes less marked the *application of cold must be reduced* to every other hour, or every third hour; too much refrigeration interferes with the nutrition of the cornea. *When the cornea is involved*, we must carefully gauge the amount of cold so as not to use an excess. In the *later stages*, when there is little swelling, and corneal infiltration or ulceration exists, *hot applications* may be indicated.

Instead of boric acid, *other cleansing and antiseptic solutions* are often used: bichloride (1:5,000, or 1:10,000), sodium chloride (0.75 per cent.), sterilized water, permanganate of potassium (1:500), etc. *Protargol* (five-per-cent. solution) is now used in this stage by many oculists; a few drops are instilled three times a day.

In the *initial stage*, if the disease be very severe, from three to six *leeches*, applied to the corresponding temple, may be of service. Occasionally there is so much *tension* that the eye cannot be cleansed on account of the difficulty in separating the lids, and in addition harmful pressure is exerted upon the eyeball; in such cases it may become necessary to widen the palpebral fissure by a division of the external canthus (*temporary canthotomy*, p. 46).

Treatment of the Later Stages: When the lids have lost their swollen and angry appearance and the discharge begins to diminish, a one- or two-per-cent. solution of *nitrate of silver* is *brushed* upon the *everted conjunctiva* once a day. This may be done even though the cornea is implicated. It is continued until the patient is well, or until the papillary swelling has persisted for some time. Then, if silver no longer exerts a favorable influence, we may apply glycerole of *tannin* (five to ten per cent.), the *alum* stick, or *sulphate-of-copper* pencil once a day.

The treatment of *corneal complications* resembles that of infected corneal ulcers, and is described in the next chapter (p. 120).

INFANTILE PURULENT CONJUNCTIVITIS OR OPHTHALMIA NEONATORUM.

An *acute purulent* conjunctivitis occurring in the *newborn*, presenting similar symptoms, complications, and course, and requiring the same treatment, as in the gonorrhœal ophthalmia of adults.

Symptoms.—The period of incubation being the same as in adults, the first symptoms are usually noticed on the *second or third day after birth;* when the onset is later than the third or fourth day, infection has taken place subsequent to the birth of the child.

The symptoms are the *same in kind as those of gonorrhœal ophthalmia*, but are often less severe, and more apt to be limited to the palpebral and retrotarsal conjunctiva. *Both eyes* are usually involved. The *cornea* is implicated in a smaller proportion of cases, especially if the affection is treated from the start. If the case is seen early, before the cornea is affected, and properly managed, this part often escapes destruction or serious damage.

The *prognosis*, therefore, *with early and proper treatment is generally favorable.*

Etiology.—*Infection* by gonorrhœal secretion from the genitals of the mother *during parturition.* In rare cases, infection occurs before birth. Sometimes it occurs *subsequent* to the birth of the child, through infection from sponges, napkins, towels, or the fingers of nurse or physician, which have been in contact with the genitals of the mother.

It is a question whether every case of ophthalmia neonatorum is produced by infection from a *gonorrhœal* vaginitis. The great majority of cases are undoubtedly of gonorrhœal origin. It is probable, however, that a few cases result through infection from simple catarrhal (non-gonorrhœal)

secretion; such exceptional cases run a mild course and are not usually complicted by corneal ulcers.

Treatment is the same as in adult purulent conjunctivitis: *Iced compresses* and *frequent cleansing* from the start; *protargol* (five per cent.) instillations; daily applications of one- or two-per-cent. solution of *nitrate of silver* after the swelling and redness have diminished and the discharge begins to be less profuse, continued throughout the stage of papillary swelling.

In applying the *iced pads*, we must be careful *not* to use them *too continuously*, as soon as the redness and swelling begin to diminish. In adults, the sensations of the patient guide us to a certain extent, and we use the pads less often when they no longer feel grateful, as happens when the redness and swelling subside. In infants, we cannot receive this information; hence great care must be used not to injure the cornea by excessive cooling, especially if there is corneal infiltration; in such cases, *hot compresses* are often substituted for the cold.

The general health of the infant must be looked after, since enfeebled conditions render treatment unsatisfactory and favor corneal complications.

Credé's Method of Prophylaxis.—Ophthalmia neonatorum is practically *preventable*. Through the adoption of Credé's method, its occurrence has been made infrequent in lying-in asylums and in private practice among the better classes. The method consists in *cleansing* the eyes of the child with water immediately after birth, and instilling one drop of a *two-per-cent. solution of nitrate of silver* into each eye; this often causes a slight redness of the conjunctiva for a day or two. It acts by *destroying any gonococci* which may have entered the conjunctival sac. Antiseptic irrigation of the vagina of the mother before delivery is also useful as a prophylactic measure.

Catarrhal Conjunctivitis in the New-Born.—Sometimes we meet with a slight catarrhal conjunctivitis in the new-

born, lasting a few days and presenting merely hyperæmia, slight swelling, and a little mucoid discharge. These are not examples of ophthalmia neonatorum. But at the start we may be in doubt whether they are not purulent cases, and it will be safer to treat them as such until the character of the inflammation becomes certain.

MEMBRANOUS CONJUNCTIVITIS.

This term comprises two clinical varieties: 1. *Diphtheritic Conjunctivitis*, and 2. *Non-diphtheritic* or *Croupous Conjunctivitis*. This subdivision is based upon the *clinical pictures* presented. The bacteriological peculiarities of the exudation may be, and often are, identical.

DIPHTHERITIC CONJUNCTIVITIS.

An *acute* inflammation of the conjunctiva, associated with exudation and *infiltration*, purulent discharge, with tendency to *necrosis* of the involved tissues. The disease is rather *rare* and occurs in *children*. It spreads by *infection*. The secretion contains the Loeffler bacillus and is *contagious*.

Symptoms.—The *lids* are very much *swollen*, *reddened*, hot, and tender. The *conjunctiva* of the lids and fornix is intensely *inflamed* and is covered by a *grayish-yellow exudation*, which also *infiltrates* the underlying tissues In this way the lids become *hard* and cannot be everted The exudation causes compression, and, as a result, there is a tendency to *sloughing* of the infiltrated parts. Besides this fibrinous exudation, there is a *discharge* of a *thin*, cloudy fluid. With these local signs, there are the *prostration* and other *constitutional symptoms* of diphtheria, and often local evidences of the disease in other parts of the body.

At the end of a week the *exudation disappears*, partly *through absorption*, partly through *necrosis and sloughing*,

causing a loss of substance covered by *granulations.* The *secretion* now becomes more *abundant* and *purulent.*

The defects in the lining of the lid gradually *cicatrize,* this process causing various *deformities:* symblepharon, trichiasis, and entropion. There is frequently *corneal ulceration.* When the diphtheritic process is severe, the cornea is seriously involved and sight is always lost

The *prognosis* in regard to sight is *always serious;* in regard to life, it depends upon the constitutional effects and general condition of the child.

Treatment.—*Prophylaxis:* The precautions described under gonorrhœal ophthalmia must be employed in this disease, to protect physician, nurse, and attendants. Besides being contagious, the disease is infectious; hence the patient should be *isolated;* other children must be removed The *second eye* must be *shielded.*

Treatment of the affected eye: Careful *cleansing* with *weak antiseptic solutions* (boric acid, corrosive sublimate). *Cold compresses* may be applied, but must be used *cautiously* on account of the enfeebled circulation. After a short period, *hot compresses* are used. When the exudation has separated, we apply a one-per-cent. solution of *nitrate of silver.* We endeavor to *prevent sequelæ* due to cicatrization, by frequent *separation of the lids* from the globe, and by keeping the two surfaces apart by a roll of cotton smeared with some bland ointment. *Corneal ulceration* must be treated as described in the next chapter.

Constitutional: We must remember that the eye affection is merely the local manifestation of a *constitutional disease.* Hence the *general treatment* of diphtheria must be kept up. Injections of *antitoxin* are of great value, producing a rapid improvement in the local as well as the general condition.

CROUPOUS CONJUNCTIVITIS OR NON-DIPHTHERITIC MEMBRANOUS CONJUNCTIVITIS.

A form of inflammation in which there is the deposit of an *exudation upon the surface* of the conjunctiva, upon which it hardens into a *membrane* There is *no infiltration into the tissues*: this constitutes the essential difference between croupous and diphtheritic conjunctivitis. *Bacteriological examination* may reveal the Loeffler bacillus and other micro-organisms, and these may be identical with those found in diphtheritic membrane. There are, however, *no constitutional symptoms* such as accompany diphtheria.

Symptoms.—Those of *catarrhal conjunctivitis*. A *fibrinous membrane forms upon the palpebral conjunctiva;* when the exudation is pulled off, a raw surface presenting a few bleeding points is seen; under such circumstances the membrane re-forms.

Etiology.—It may be caused by *irritants* (mechanical, chemical, or thermic), or by the action of various *micro-organisms*. Examples of the former are nitrate of silver, acids, lime, molten lead, burns, and injuries in general.

Treatment.—That of catarrhal conjunctivitis. As soon as the membrane shows no tendency to re-form, application of one-per-cent. solution of *nitrate of silver* are useful.

GRANULAR CONJUNCTIVITIS, TRACHOMA OR GRANULAR LIDS.

An inflammation, generally of *lengthy duration*, accompanied by *hypertrophy of the conjunctiva* and the formation of "*granules*," with subsequent *cicatrical changes* It is a *common* disease and occurs at *all ages*. There is more or less *secretion*, which is *contagious*. It is a very important affection on account of its disastrous complications and

sequelæ, which are responsible for many cases of partial or total blindness.

Subjective Symptoms.—More or less *photophobia*, *lachrymation*, *itching* and burning sensations, feeling of foreign body, *pain*, and *visual disturbance*.

Objective Symptoms.—*Swelling* of the lids, *narrowing* of the palpebral aperture, and *drooping* of the upper lid (from weight and swelling). There is a variable amount of *muco-purulent discharge*, marked in recent cases, scanty in chronic forms. The *conjunctiva* of the tarsus and fornix is *reddened*, thickened, and uneven, on account of *hypertrophy* and the occurrence of *granules*. The ocular conjunctiva is often somewhat injected.

Forms.—Basing the subdivision upon variations in local appearances, we distinguish three forms: (1) *papillary*, (2) *granular*, and (3) *mixed*.

(1) *Papillary Form.*—A large number of small elevations (*papillæ*) are seen upon the greatly *thickened conjunctiva*, giving the latter a *velvety* appearance, or, if the papillæ are larger, a granular aspect. This form affects only the *tarsal* conjunctiva, and usually only the *upper lid*. The papillæ are caused by the *hypertrophied conjunctiva* being thrown into *folds*, covered by an increase in epithelium, the connective-tissue interior being infiltrated with cells.

FIG. 66.—Trachoma.

(2) *The Granular Form* presents a preponderance of *trachoma granules* (Fig. 66). These are grayish or yellowish, *rounded*, *translucent bodies* showing through the conjunctiva They may be *small and rounded*, larger and *warty*, or *flattened* and succulent. They are present principally in the *fornix*, and when numerous are arranged in *rows*. In the tarsal conjunctiva they are less numerous, smaller,

and less distinct, being hidden by the papillæ. Occasionally, trachoma granules are formed upon the semilunar folds and the bulbar conjunctiva The granules are rounded *collections of lymph corpuscles* in a *connective-tissue reticulum*, resembling what we see in Peyer's patches in the intestines; they may present an incomplete capsule in old cases.

(3) *The Mixed Form* represents the *common* condition, the papillary and granular varieties being almost always found together, the former more prominent in the palpebral conjunctiva, the latter predominating in the fornix. Occasionally the two forms occur separately.

Course.—The process *progresses* up to a certain point, and is then followed by *cicatricial changes* in the conjunctiva (*cicatricial stage*). This cures the trachoma, and the *papillæ and granules disappear;* but the conjunctiva does not return to a normal condition, the cicatricial changes and contraction leading to certain *sequelæ;* the seriousness of the latter depends upon the severity of the process and the amount of hypertrophy and subsequent cicatrization. In the tarsal conjunctiva the cicatricial process causes *narrow, whitish bands and scars* (Fig. 67), sometimes a network; in advanced and severe cases the entire surface may be replaced by a pale, smooth *cicatricial membrane.* In the fornix, cicatrization changes the conjunctiva into a pale, bluish-white membrane, and as a result of contraction the *transition fold is shortened* or disappears.

Clinical Varieties.—Clinically, trachoma presents a number of varieties. In some cases the invasion is acute, *acute trachoma*, and accompanied by marked inflammatory symptoms and profuse purulent discharge; such cases resemble purulent conjunctivitis. The presence of the trachoma granules serves to differentiate, but frequently the swelling hides these; we may have to wait several days, until the swelling subsides somewhat, before we can decide. *Such acute* cases are not common.

Frequently the disease *begins insidiously;* it may exist unknown for months, before the subjective symptoms become annoying. *Most cases* of trachoma are *chronic* in their course, and the duration is months and years.

Knapp divides chronic trachoma into (1) *inflammatory trachoma,* with inflammatory symptoms, very *contagious,* leading to *cicatrization* of the conjunctiva and various *sequelæ* when unchecked; and (2) *simple or non-inflammatory trachoma,* in which, with moderate or marked deposition of *granulations* of the granular form in the palpebral and retrotarsal portions of the conjunctiva of both lids, there are but *slight or no symptoms of irritation* or discomfort; the latter form he believes to be *non-contagious.*

Besides these differences in the intensity of the inflammatory symptoms, there are great variations in the amount of change in conjunctiva and cornea. There are *mild cases,* in which there are but little hypertrophy and insignificant cicatricial changes in the conjunctiva, so that afterward we can scarcely be sure that trachoma has existed; such mild cases are apt to remain free from corneal complications.

In *moderate and severe cases* there always remain *permanent cicatricial changes,* which enable us to diagnose the previous existence of trachoma. When the cornea is implicated, the case is always a *serious* one.

Trachoma does not always progress uninterruptedly; there are often *intermissions and exacerbations. Relapses* are quite frequent, especially when treatment has been discontinued too soon.

Complications.—The most frequent are *pannus* and *corneal ulceration,* both causing disturbance of sight.

Pannus consists of a newly formed *vascular tissue,* which usually covers the upper part of the cornea (Fig. 67). The affected portion of the cornea presents a *cloudy* appearance, and is grayish and translucent; its surface is *uneven* and *vascularized,* the blood-vessels springing from the con-

junctival vessels at the limbus. The process advances until it covers the *upper half of the cornea*. Finally, the entire cornea may be covered, in which case *vision is reduced* to perception of light. Unless subsequent changes occur, complete retrogression is possible, so that the cornea can become transparent again. In marked cases *iritis* is apt to develop. Pannus is not merely due to mechanical irritation, but to a change similar to that which occurs in the conjunctiva.

FIG. 67.—The Cicatricial Stage of Trachoma, with Pannus.

Ulcers of the Cornea occur with or without pannus. They leave *opacities*, which interfere with vision according to their seat and density.

Sequelæ.—Complete cure is usually effected in the mildest cases alone, or in more severe forms only when they are subjected to early treatment. *Sequelæ are very common*, affect the conjunctiva, cornea, and lids, and produce *permanent disability* of the eye.

1. *Trichiasis and entropion* occur as a result of cicatricial contraction of the conjunctiva with curving of the tarsus; they are more pronounced in the upper lid. As a result of this distortion of the lid with consequent changes in the position of the cilia, there is mechanical interference with the cornea, causing ulceration.

2. *Ectropion* (usually of the lower lid) follows in some cases, as a result of hypertrophy of the conjunctiva and contraction of the orbicularis.

3. *Symblepharon* results from cicatricial contraction of the conjunctiva; when considerable, there is obliteration of the fornix. This condition restricts the movements of the eyeball.

4. *Corneal opacities* result from pannus and corneal ul-

cers. After lasting some time, pannus changes into a thin, permanent layer of connective tissue.

5. *Staphyloma of the cornea* follows in some cases.

6. *Xerosis*, a contracted, dry, and scaly condition of the conjunctiva, with changes in the cornea, may occur in very severe cases.

Etiology.—Trachoma is caused by *contagion* from another eye, being transferred *through the secretion*. The danger of contagion depends upon the amount of secretion in any given case. The transfer from one eye to another may take place by the finger, but usually by *towels, handkerchiefs*, and the like, which are used in common by many persons. Hence the disease spreads most extensively in *schools, asylums, and barracks*, and among people who live *crowded* closely together, and who are careless in regard to *cleanliness*. It is found most frequently among the *poorer classes*. *Certain races* seem predisposed—the Jews and the Irish. It occurs with especial frequency in *certain countries* —Arabia, Egypt; the latter country is infected with it; during the Napoleonic wars the affection was carried to Europe by soldiers (hence often called *Egyptian ophthalmia*). In Europe it occurs much more extensively in the east than the west, and much more frequently in low lands (Belgium, Holland, Hungary) than in elevated countries (Switzerland). In America the negro race is comparatively free from the disease. The contagious principle in the secretion is thought to be a *micro-organism;* a number of such have been described, but thus far no conclusive results have been arrived at.

Treatment consists in an attempt to reduce the inflammatory symptoms and secretion, and to check and remove hypertrophy of the conjunctiva, thus shortening the duration and diminishing the liability to conjunctival cicatrization and to sequelæ. This is accomplished either by the use of certain *irritating applications*, or by *mechanical (surgical) means*.

Irritating Applications: Sulphate of copper in the form of a crystal or pencil is the favorite local application. *Nitrate of silver* (one- or two-per-cent. solution), glycerole of *tannin* (five to twenty-five per cent.), and the *alum* stick are also employed.

Mechanical (Surgical) Treatment includes expression, grattage, excision, curetting, electrolysis, and galvano-cautery. *Expression* is by far the most popular of these mechanical methods, and has the widest range of usefulness. The *kind of treatment* best suited for trachoma depends upon the *nature of the affection*, the presence or absence of *inflammatory symptoms*, and the *stage of the disease*. *Mechanical treatment* is indicated in the granular and mixed forms of trachoma, with well-marked translucent granulations, when there is an absence of severe inflammatory symptoms; it is particularly useful in the form which Knapp calls *simple or non-inflammatory*. *Irritating applications* are indicated as supplementary treatment to surgical procedures, and for cases of chronic trachoma, in which the granulations are of small size, or of the papillary variety, particularly when there is considerable *thickening of the conjunctiva*.

In *acute* forms and in acute exacerbations of chronic cases, when there is *much discharge*, solution of *nitrate of silver*, one or two per cent., is applied to the conjunctiva, the excess being washed away with water or salt solution. In many cases of this sort, however, it is often advisable to suspend temporarily all irritative treatment and to prescribe *cold compresses* and *mild* cleansing and *antiseptic washes*.

During the *cicatricial stage* copper is no longer indicated; the ointment of the *yellow oxide of mercury* is then of service.

If treatment is not continued until every trace of hypertrophy has disappeared, *relapses are very common*.

of (...he pencil is applied to the *everted*

lids once a day, or every other day; it is drawn *lightly* across the conjunctiva two or three times, but applied only to the *hypertrophied portions*. The application should include the palpebral portion of the *transition fold* of the upper lid; in passing the copper stick under the tarsus, the cornea is protected by the lower lid. The stick of copper sulphate should have a *flat, blunt end*, as shown in Fig. 68, and not be pointed or conical. After each application, the *excess* of copper sulphate is *washed off* with water or solution of boric acid; subsequently *iced compresses* are applied for half an hour or longer. This treatment is *continued for months*, until every trace of hypertrophy has disappeared; after a while the applications are made more lightly and less frequently.

FIG. 68.—Sulphate of Copper Stick.

Expression is best performed with Knapp's roller forceps, by means of which the granulations are *squeezed out* between two *fluted rollers* at the end of the shafts (Fig. 69). The operation is painful and a *general anæsthetic* is required. The upper lid is everted and the trachoma follicles are squeezed out between the two extremities of the forceps. One extremity is passed back into the fornix and the other over the tarsus; using moderate compression, the forceps is drawn forward, pressing out the contents of

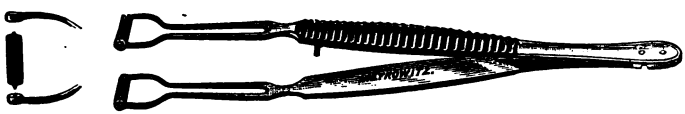


FIG. 69.—Knapp's Roller Forceps for Trachoma.

the granules. This procedure is repeated until the lid is free from granulations and presents a dark-red surface with small red points. The lower lid is then operated upon in the same manner. After *expression*, the conjunctiva is often brushed vigorously with a solution of *mercuric bichloride*,

1:500. Care must be taken *not to cause abrasions of the cornea* and *not to tear the conjunctiva*. If the granulations are hard and horny, it may be well to scarify them before using the roller forceps. There are swelling and ecchymosis for a day or two after the operation, but no other evidences of reaction. *Cold compresses* and *irrigations* with solution of boric acid are indicated for several days; then any remaining roughness is treated with gentle applications of the sulphate of *copper* crystal every other day for a few weeks, or until the lids are normal.

The other mechanical or surgical means of treating trachoma are used much less frequently than expression. *Grattage* consists in scrubbing the granulations, with or without previous scarification, with a stiff toothbrush until all the granules are removed, and then thoroughly rubbing in a solution of mercuric bichloride, 1:500. *Excision* consists in the removal of the fold of conjunctiva, about 10 mm. broad, containing the granules. Both of these methods cause more injury to the conjunctiva than is the case with expression.

Treatment of Complications.—Recent *pannus* is best relieved by the treatment of the conjunctiva. In addition, we may use *atropine* occasionally, so as to keep the pupil dilated and prevent posterior synechiæ, since iritis is frequently present in these cases. If the pannus is very dense, we may apply the copper directly to the cornea. The operation of *peritomy*, the excision of a narrow strip of conjunctiva surrounding the cornea with a view of cutting off the vascular supply, is occasionally performed for the relief of severe cases of pannus. For active *ulceration*, *nitrate of silver* is often used, and *atropine*, if iritis is suspected.

General treatment must not be neglected. The eye should be kept *cleansed* by the frequent use of solution of salt, boric acid, or bichloride of mercury (1:10,000). The *hygienic surroundings* of the patient should be made

as perfect as possible, with proper *ventilation*, plenty of *out-door exercise*, and *good food*.

Prophylaxis is very important. The patient and his family must be warned of the *contagiousness* of the secretion, and impressed with the necessity for keeping the patient's handkerchiefs, towels, wash-basin, etc., apart from those of other persons. In schools, asylums, institutions, and barracks, the *prevention of epidemics* of trachoma is a very serious matter, requiring constant vigilance, careful inspection of every new addition or inmate, and the *isolation* of trachoma cases so long as the latter are capable of conveying the disease.

PHLYCTENULAR CONJUNCTIVITIS.

This disease, also known as *pustular conjunctivitis* and as *scrofulous ophthalmia*, is a *circumscribed* inflammation of the conjunctiva, accompanied by the formation of one or more small reddened projections called *phlyctenulæ*. The latter consist of accumulations of lymphoid cells, which soften at their apices, forming small *ulcers*. The phlyctenulæ may occur upon the *ocular conjunctiva*, and then the disease is called *phlyctenular conjunctivitis;* they may occur upon the *cornea*, when the affection constitutes *phlyctenular keratitis;* or they may occur, and most frequently do occur, at the *limbus*, and then we might speak of the disease either as a keratitis or as a conjunctivitis. Very frequently they occur in all three situations in the same individual. The pathology, symptoms, and treatment being the same in all cases, it is convenient to describe the three varieties collectively under the title of *phlyctenular ophthalmia*.

Objective Symptoms.—The essential sign is the occurrence of one or more *small, reddish elevations*, or nodules, about the size of a millet seed, at some part of the *conjunctiva* or *cornea*, frequently at the *limbus*. The phlyc-

[illegible] *conjunctival hyperæmia* [illegible] The [illegible] of the ocular conjunctiva [illegible] changed from the normal. The phlyctenule [illegible] a small elevation at its apex, which [illegible] the level of the surrounding conjunctiva. It [illegible] without leaving behind any [illegible] in the conjunctiva. The entire process lasts from a *few days* [illegible]

Fig. 74.—Phlyctenule of the cornea.

Generally, a *number of phlyctenulæ* appear at the same time; in this manner the entire ocular conjunctiva may be exhibened; in such cases the palpebral conjunctiva will be congested. The exudate may become absorbed without going through the stage of ulceration.

When the phlyctenulæ appear upon the cornea, the *ulcers* are usually superficial and heal without the production of changes in the cornea. But sometimes they spread into the corneal substance, and then leave a *permanent opacity*. The ulcer may even perforate the cornea; or a number of them may, by confluence, spread along its surface.

Fascicular Keratitis.—The ulcer resulting from the phlyctenule may advance from the margin to the centre of the cornea, drawing after it a fascicle of blood-vessels. In this manner there is formed a *narrow, red band of* vessels, extending some distance over the cornea; at the apex of this fascicle is seen a *small, gray crescent*, corresponding to the advancing margin of the ulcer, which has healed in the peripheral parts. This form of ulceration always remains *superficial*; when the process terminates, the blood-vessels gradually disappear and a superficial linear opacity remains.

The phlyctenule may, in severe cases, involve the *deep layers* of the cornea, forming an *infiltration;* this either be[illegible]rbed completely or leaves an *opacity* of the

cornea; or it may become purulent and a deep *ulcer* result.

There is usually considerable *lachrymation*, but *no secretion;* if there is any discharge, it is mucous or mucopurulent and not abundant.

Subjective Symptoms.—*Photophobia* is pretty constant; it may be slight or marked. When prominent, there is considerable *blepharospasm*, and the eyes can be examined only with difficulty.

Course.—The phlyctenules usually occur in *crops:* before one is completely cured another is apt to appear. In this way the course may become *protracted* and may extend over weeks. Each phlyctenule lasts from a few days to a week or two. *Relapses* are very common. The affection occurs most frequently in *children* and in young persons, but is also seen in adults. In adults a single large phlyctenule often gives the local appearances of episcleritis.

As a result of constant *lachrymation*, there are frequently added *blepharitis, excoriations,* and *eczema* of the lids.

The *prognosis is favorable;* serious results are rare. The phlyctenulæ frequently leave no traces. In some cases *slight corneal* opacities remain, and if these are central, sight will be interfered with.

Etiology.—The disease is very *common*. It seems dependent upon some *constitutional error*. It occurs frequently in *children* who suffer from the *tuberculous* or *so-called scrofulous* diathesis. It is especially frequent among the *lower classes,* in whom dirt, poor food, and improper hygienic surroundings are contributory factors; also in children debilitated from disease. We are apt to see other manifestations of the predisposing diathesis, such as swelling of the cervical lymphatic glands, eczema, coryza, blepharitis, chronic otorrhœa, etc. Sometimes, however, the affection occurs in children of the better classes, apparently in good health.

Treatment.—*Local: Calomel* dusted upon the eyeball

once a day; this is believed to be slowly changed to corrosive sublimate by the action of the tears, and in this way to keep the eye bathed in an antiseptic fluid. A favorite remedy is the *ointment of the yellow oxide of mercury* (one or two per cent.); a piece about the size of a hempseed is deposited in the conjunctival sac and rubbed about with the lids. When there is a great deal of irritation, it is wise to withhold the yellow oxide ointment until less inflammation exists. If the symptoms of irritation are very prominent, it is better to irrigate with *solution of boric acid*, and to apply *cold pads* if the phlyctenulæ involve the conjunctiva, and *hot compresses* if they form upon the cornea.

If there is infiltration or *ulceration* of the cornea, *atropine, hot compresses*, and *mild antiseptic* washes are indicated. If there is *fascicular keratitis*, the ointment of the *yellow oxide of mercury* is employed; in such cases, we can often cut short the progress of the disease by *cauterizing* the advancing edge of the ulcer with a fine *galvano-cautery* point (Fig. 73), or with tincture of *iodine*. Bandages should *not* be applied; it is only in extreme cases of very deep ulceration that a bandage is indicated.

The *photophobia and blepharospasm* are often very annoying symptoms. An excellent plan of reducing them is to *forcibly dip* the entire face of the child into a *basin of cold water*, and hold it there until the child opens its eyes; this plan repeated several times a day often relieves this troublesome condition, and has a favorable influence upon the course of the disease by diminishing pressure upon the eyeball. In extreme and persistent cases of blepharospasm, if nothing else answers, temporary canthoplasty (p. 46) may be resorted to.

General treatment is of great importance. Suitable and *nourishing diet, improved hygienic surroundings*, and cold sponging and *bathing* are useful. The *nose* should receive proper treatment. These patients should not be allowed to

remain in the house and in the dark, as they are inclined to do on account of the photophobia. *Smoked glasses* are prescribed to relieve this symptom. Preparations of *iron* (syrup of the iodide), *quinine*, and *arsenic* are useful for internal administration, and *cod-liver oil* is of great benefit.

SPRING CATARRH.

A rather *uncommon* disease of the conjunctiva, of *chronic* course, lasting for years, continuing *during warm weather* and disappearing entirely or to a considerable extent with the beginning of winter. It is also known as *vernal catarrh*. The disease occurs chiefly in *children*, most frequently in boys. It may attack the tarsal or the bulbar conjunctiva, or both.

Objective Symptoms.—The *tarsal conjunctiva* presents *flattened papillæ* covered by a delicate, *bluish-white film*. The *bulbar conjunctiva* presents at the inner and outer portions of the limbus *hard, gelatinous hypertrophies*, which may extend into the cornea for a short distance, and which sometimes surround it. During the *winter* these changes become less marked or *disappear;* they *return* with the advent of *warm weather*.

Subjective Symptoms include a feeling of *heat, lachrymation, itching*, and *photophobia;* these become *worse in warm weather* and disappear in the winter.

Course.—The disease usually attacks *both eyes* and lasts in this intermittent way for several years or longer, finally becoming extinct and leaving no traces behind. Its *etiology* is *unknown*.

Treatment.—There is no known cure. The subjective symptoms can be made less annoying by the *remedies* in use for *catarrhal conjunctivitis*. Cocaine may be of value. If the hypertrophies are of considerable size, they may be removed. When the granulations are large, *bluestone* or *expression* may be of service. The treatment most fre-

quently used is boric acid and white precipitate ointment; acetic acid (one drop of the dilute acid to half an ounce of water) has also been used with some improvement.

SYMBLEPHARON.

A *cicatricial attachment* between the conjunctiva of the *lid* and the *eyeball*. It may affect both lids, but usually the *lower;* sometimes it includes part of the cornea. It is called *anterior* or *partial*, when extending bridgelike from lid to globe, leaving a free portion of conjunctiva corresponding to the fornix; *posterior*, when it involves only the fornix; and *complete* when it affects all the conjunctiva. It is *caused* by the *junction* of two opposing *granulating surfaces;* hence, it occurs after *injuries*, especially burns from lime, acids, and molten metal; sometimes it follows *trachoma*, and occasionally diphtheritic conjunctivitis.

Symblepharon *interferes* with the *movements of the eyeball*, and this may cause diplopia. Traction upon the adherent parts excites *irritation*. In severe cases the cornea is included and sight interfered with; or, if there is inability to close the lids, lagophthalmos and its sequelæ may be present.

Treatment.—If *anterior and not extensive*, we divide the band and keep the two raw surfaces from uniting by *separating* them daily with a probe until they have cicatrized separately; the interposition of a small roll of cotton saturated with some bland oil or ointment may aid in this purpose. Or the band may be ligated and the ligature allowed to slough through.

In *more severe forms*, and in all cases of posterior and complete symblepharon, the treatment is generally *unsatisfactory*. The separated raw surfaces must be *covered with conjunctiva* or with *grafts* of skin or mucous membrane to keep them from uniting. This may be done (1) by *loosening* the adjacent bulbar conjunctiva and sewing it over the de-

fect, (2) by *transplanting* pieces of mucous membrane from the lip or from the rabbit's conjunctiva, (3) by *skin flaps* passed from adjacent surfaces, and (4) by *Thiersch skin grafts*, taken from other parts of the body and supported on an artificial eye until adhesion has taken place; the last method gives some promise of success.

PINGUECULA.

A small, slightly raised *spot of yellowish color* situated at the inner and outer sides of the cornea, especially marked in *old people*. It is not formed of fat as its name implies, but of *connective-tissue* thickening of the conjunctiva. It never calls for interference.

PTERYGIUM.

A triangular fold of membrane, extending from the inner or outer part of the ocular conjunctiva to the cornea (Fig. 71); the apex is immovably united to the cornea, the base spreads out and merges with the conjunctiva.

FIG. 71.—Pterygium.

Symptoms.—When recent, pterygium is rich in blood-vessels and hence of a red color; later it changes into a *white, tendinous membrane*. It *grows slowly* toward the centre of the cornea, giving rise to moderate symptoms of *conjunctival irritation*, and it may eventually cover a considerable part of the cornea; finally it becomes *stationary*. Besides more or less irritation, it causes *disfigurement*, and it spreads over the cornea *interfering with vision*. It is generally situated to the *inner side* of the cornea, less frequently to the outer side or in both locations. It may occur in one or both eyes.

Etiology.—Pterygium is thought by some to originate

from pinguecula, the process extending to the cornea and drawing the conjunctiva after it. It occurs in *elderly persons* who are exposed to *wind or dust* (farmers, coachmen, masons, sailors). It is uncommon among the better classes.

Treatment consists in *removal* by one of a number of different *operative methods*. The pterygium may be *dissected away* with a sharp scalpel, or Beer's knife (Fig. 34), and *cut off*, the conjunctival defect being closed by uniting the upper and lower borders, undermining the conjunctiva if necessary to bring the edges together. The *apex* of the pterygium must be thoroughly *excised* from the cornea, and its attachment in this situation *scraped or cauterized* with the actual cautery, to prevent recurrence. Instead of cutting off the pterygium, it may be dissected up and *stitched underneath the detached conjunctiva*, either above or below; or it may be divided into two halves, of which one is *transplanted* above and the other below, being held in the conjunctival pocket by a stitch.

SUBCONJUNCTIVAL HEMORRHAGE.

Bright or dark red patches involving more or less of the bulbar conjunctiva, unaccompanied by inflammatory symptoms. *Ecchymosis* is seen after *injuries*, *operations*, and *inflammations* of the eyeball. It is frequently observed in the healthy conjunctiva in *old persons*, in whom the walls of the blood-vessels are brittle, being excited by various straining efforts, and in children after whooping-cough. It is of *no importance* and becomes *absorbed* within a week.

INJURIES OF THE CONJUNCTIVA.

These are very common, and include:

1. *Foreign bodies in the conjunctival sac*, consisting of dust, iron, coal, or ashes. They usually adhere to the *inner surface of the upper lid*, causing severe pain and irritation, and are readily removed after eversion of the lid.

2. *Wounds.*—If possible, wounds of the conjunctiva should be closed with a stitch.

3. *Burns* are quite common, being due to boiling water, steam, lime, mortar, molten metal, and acids. Following the accident a *grayish eschar* forms; this separates and leaves a *granulating* surface, which heals by *cicatrization;* in this way *symblepharon* often results.

The treatment consists in the *complete removal* of the caustic substance as soon as possible. Solid particles are removed with cotton or forceps. Then the conjunctival sac is *washed out* with solutions which tend to *neutralize* the corrosive substance or render it insoluble. In the case of lime, mortar, or caustic alkalies, we use milk or a weak solution of vinegar; or we may wash out the eye with oil. If the corrosive agent consisted of an acid, the eye is irrigated with a weak solution of sodium bicarbonate. Subsequently we use *cold compresses, atropine,* and sometimes a bandage. After the loosening of the eschars, we must *separate the adhesions frequently.* Symblepharon often occurs notwithstanding the greatest care.

CHAPTER VIII.

DISEASES OF THE CORNEA.

Anatomy.—The cornea is the clear, transparent, anterior portion of the external coat of the eyeball; it is nearly circular in shape, but is slightly wider in the transverse than in the vertical direction; its radius of curvature is somewhat shorter than that of the sclerotic; the junction of the two is known as the *limbus*, but their tissues are in complete continuity. The cornea is composed of *five layers*, from without inward: (1) Layer of epithelial cells; (2) Bowman's membrane; (3) the proper substance of the cornea; (4) Descemet's membrane; and (5) a layer of endothelium.

The epithelium covering the front of the cornea is of the stratified variety, formed of flattened, scaly epithelial cells superficially, of polygonal cells beneath these, and of columnar cells most deeply. Practically it is part of the bulbar conjunctiva.

Bowman's membrane is a thin, homogeneous membrane which separates the corneal epithelium from the proper substance of the cornea. Although usually described as a separate membrane, it is really a part of the corneal substance, and when highly magnified is seen to be composed of fine fibres which are intimately connected with the subjacent layer.

The proper substance of the cornea, the thickest layer, is formed of connective tissue arranged in *lamellæ*, the planes of which are parallel to the surface of the cornea; these are connected with one another and cross at right angles in alternating layers. The ultimate fibrils of which the

lamellæ are composed, as well as the different bundles of fibrils forming the lamellæ, are held together by means of a transparent *cement* substance. The corneal substance is traversed by a system of spaces or *lacunæ*, situated in the cement substance separating the laminæ, and sending off prolongations in every direction; these form small *canals* by means of which the lacunæ of the same plane and those placed above and below communicate. The spaces are partly filled with branching cells (*corneal corpuscles*), the branches of the cells passing into the small canals and communicating with adjoining cells. The cells do not completely fill the lacunæ, but leave room for the passage of *lymph* and lymph corpuscles. The proper substance of the cornea passes uninterruptedly into the sclera.

Descemet's membrane (the posterior elastic lamina) is a thin, firm, structureless, transparent, and highly *elastic layer*, placed posterior to the proper substance of the cornea; at the periphery of the cornea it passes over into radiating bundles of elastic fibres which form the *ligamentum pectinatum*.

Posteriorly, next to the anterior chamber, is a single layer of flattened, hexagonal cells, the *endothelium*.

The cornea is not provided with blood-vessels. The *capillary loops* from the anterior ciliary vessels form a ring around the circumference of the cornea. Its nutrition is provided for by the system of lymph canals just described. It is richly supplied with *nerves* derived from the *ciliary nerves*.

The line between cornea and sclera is known as the *limbus*. Near the margin of the cornea, just within the sclero-corneal junction, we frequently find an opaque, whitish ring or part of a ring; this is known as the *arcus senilis*; it is due to a deposit of fatty granules, and most frequently occurs in advanced age, though occasionally it is found in younger persons.

INFLAMMATIONS OF THE CORNEA.—KERATITIS.

Keratitis in general presents the following symptoms:

Objective Symptoms.—(1) *Infiltration*, with dulness of surface and diminution of transparency; this may be followed by (a) *complete absorption* of the infiltration, (b) *incomplete absorption*, leaving opacities, and (c) *suppuration*, with formation of an *ulcer*. (2) Limited or general *vascularization*, the blood-vessels being derived from the conjunctival loops at the limbus. (3) *Circumcorneal injection*. (4) There is often a complicating *conjunctivitis* with chemosis. (5) Neighboring deep parts are frequently involved (*iris* and *ciliary body*), as a result of which there may be pus in the anterior chamber (*hypopyon*).

Subjective Symptoms.—*Pain*, *photophobia*, *blepharospasm*, *lachrymation*, and *interference with vision*.

Varieties.—Keratitis may be divided into *suppurative and non-suppurative*.

Suppurative Keratitis.—The common forms are (1) phlyctenular keratitis, and (2) ulcers of the cornea. The uncommon forms are (3) keratitis from imperfect closure of the eyelids (lagophthalmos), (4) neuroparalytic keratitis, and (5) xerotic keratitis.

Non-suppurative Keratitis.—The common forms are (1) interstitial keratitis, and (2) vasculo-nebulous keratitis (pannus). The uncommon forms are (3) vesicular keratitis, (4) keratitis profunda, (5) sclerosing keratitis, and (6) ribbon-shaped keratitis.

Phlyctenular Keratitis has been described under the title *Phlyctenular Conjunctivitis* (p. 103), and the special symptoms arising when the cornea is involved have been pointed out.

ULCER OF THE CORNEA.

An infiltration, followed by suppuration and *loss of substance* of the cornea. The affection is of very *common* occurrence.

Subjective Symptoms.—*Pain, photophobia, lachrymation,* and *blepharospasm.* Sometimes all these symptoms are slight, or even absent, and yet the ulcer may be a very extensive and serious one.

Objective Symptoms.—An ulcer begins with a dull, grayish, or grayish-yellow *infiltration* of a circumscribed portion of the cornea; *suppuration* takes place in this area, the superficial layers are cast off, and thus there is *loss of substance.* The process may progress in two directions: it may either travel over the cornea so as to involve a *greater area,* or it may become *deeper;* it may extend both in area and in depth. Very often the advance takes place in one direction, across the cornea; sometimes there is at the same time a tendency to heal at the opposite side, so that the ulcer merely changes its situation (creeping or serpiginous ulcer). There is nearly always more or less grayish *infiltration* of the cornea immediately *surrounding* the loss of substance, and considerable *ciliary injection.*

If the ulcer is small and superficial, it will cleanse itself in the course of a few days. The destroyed portion of the cornea will be cast off, the infiltrated border will become clear, and repair set in; this is accompanied by the appearance of blood-vessels which spring from the limbus; the process terminates in cicatrization. When the ulcer is very superficial, the cornea may remain perfectly transparent. But when some of the proper substance of the cornea has been destroyed, new connective tissue takes its place, and such a scar is always more or less *opaque.* The seat of the ulcer may also be marked by a slight depression (*corneal facet*).

The detection of the extent of infiltration and ulceration is facilitated by the instillation of a few drops of a two-per-cent. solution of *fluorescein*, which stains green all such ulcerated or infiltrated parts.

When the ulcer is deeper, both subjective and objective symptoms are more pronounced, and the complications and sequelæ are more serious. *Neighboring structures* give evidences of inflammation: *conjunctivitis*, congestion of the iris, even *iritis* with its symptoms, including hypopyon. *Hypopyon* is a collection of pus in the anterior chamber. The pus is not derived from the ulcer as was formerly supposed, but is an exudation from the inflamed iris and ciliary body. It collects at the bottom of the anterior chamber (Fig. 72), or it may partially or completely fill this space. It may either remain fluid, or when mixed with fibrin it may form a semi-solid, globular mass. Such an ulcer may heal with no other permanent injury except marked corneal *opacity*, or there may be bulging (*anterior staphyloma*). But deep and spreading ulcers frequently have their course modified by the occurrence of *perforation* of the cornea, which, in healing, affects the usefulness and safety of the eye in various ways.

Perforation of the Cornea is often preceded by a *protrusion of Descemet's membrane* through the floor of the ulcer, forming a small, transparent vesicle. Perforation may be spontaneous, or it may be caused by increased pressure resulting from the blepharospasm, various straining efforts, such as crying, sneezing or coughing, or occasionally by force exerted in examining the eye. The aqueous humor escapes, often carrying the iris into the wound; the eye feels soft; the anterior chamber is obliterated, and iris and lens are in apposition with the cornea. Perforation of the cornea has a favorable effect upon the course of the affection: the subjective symptoms are relieved and the ulcer begins to heal as a result of diminished tension.

When the opening closes by *cicatrization*, the iris may

regain its normal position. But frequently it continues *adherent* to the walls of the perforation, or remains *prolapsed* and becomes incorporated with the scar. Such a condition is called *anterior synechia;* and since the cicatrix forms a dense, white opacity of the cornea, it is known as *adherent leucoma.* Most frequently only a portion of the iris is drawn into the scar; the pupil is then more or less pear-shaped. Occasionally the entire pupillary margin may be adherent, causing *occlusion of the pupil.*

At the time of perforation, the *lens* may become dislocated, and occasionally it escapes. When it is pushed forward and lies in apposition with the margins of the opening and then recedes after the anterior chamber is re-established, it frequently presents a proliferation of the subcapsular epithelium which has become irritated by the pressure of the lens upon the cornea, forming a white spot upon its anterior surface (Fig. 127), known as *anterior capsular or anterior polar cataract* (p. 214).

Occasionally the perforation fails to close and a *fistula of the cornea* results; this condition exposes the eye to subsequent serious inflammation and jeopardizes its safety. *Irido-cyclitis* and even *panophthalmitis* may follow perforation, especially if the suppurative process be a virulent one.

Etiology.—Ulcers of the cornea are usually found in *adult and aged* individuals; phlyctenular ulcers are the only ones which are common in children. Ulcers are much more frequent among the *lower* than among the better *classes,* and occur often in individuals in whom the *general health is poor.*

The process is essentially an *infection* by various microorganisms; the latter are frequently introduced by the secretion of chronic *conjunctivitis,* and especially by that of *dacryocystitis.*

The exciting causes are: (1) traumatism (foreign bodies, injuries); this is the most frequent cause; (2) conjunctival inflammations (gonorrhœal ophthalmia, ophthalmia neona-

torum, trachoma, diphtheritic conjunctivitis); (3) phlyctenular keratitis; (4) disturbances in the nutrition of the cornea (paralysis of trigeminus, keratomalacia, glaucoma); (5) infection during operations; (6) variola; (7) herpes.

Clinical Forms.—Certain variations in the course of corneal ulcers have already been considered. The nomenclature of ulcers of the cornea is quite extensive and is founded upon peculiarities in the symptoms or course. The following warrant special mention:

Simple Ulcer is the name often given to a small and superficial ulcer, with symptoms of slight or severe irritation, no tendency to perforation, terminating in uncomplicated healing; phlyctenulæ and slight injuries often cause such ulcers.

Deep Ulcer is one which shows a tendency to involve the deeper layers and to perforate rather than to spread over the cornea. The symptoms are apt to be marked, the iris is usually involved, and hypopyon is often present; hence the results are often serious.

Serpent Ulcer (*Ulcus serpens*, *Infected Ulcer*, *Hypopyon Keratitis*) is a very *common* and *virulent* form, in which the process tends to *spread* over a considerable portion of the cornea and at the same time extends into its *depth*. The subjective *symptoms* are apt to be *marked*, though occasionally they are slight. The process begins as a grayish-yellow infiltration near the centre of the cornea, rapidly changing to an ulcer with sloughing margins, especially at the advancing side where there is frequently a yellowish crescent (Fig. 72). The rest of the cornea is often dull, gray, and infiltrated. The process *advances very rapidly*, much of the cornea becomes destroyed, and *perforation* takes place. There is early and

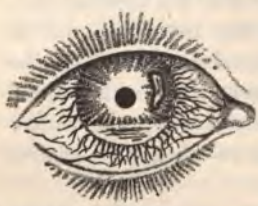


FIG. 72.—Infected Ulcer, with Hypopyon.

intense *iritis*, and *hypopyon* is almost always present. Owing to the virulence of the ulcer and the accompanying iritis, *much damage* results to the eye. Adhesion and prolapse of the iris are frequent, the pupil is often occluded, and iridocyclitis and panophthalmitis are not uncommon. Considerable opacity of the cornea always ensues, and often staphyloma. There is, therefore, considerable impairment of vision, which not infrequently is reduced to perception of light.

Rodent ulcer is a rare form, of slow course, in which the ulceration always remains superficial, but most of the cornea becomes involved, and thus the resulting opacity and interference with vision are pronounced. It commences at the periphery and extends toward the centre of the cornea, being intermittent in its progress.

Marginal Ring Ulcer is rare, of slow and intermittent course, successively involving different parts of the margin, so that it tends to extend all around the cornea.

Transparent Ulcer is small, superficial, central, shows no tendency to spread or to perforate, occurs chiefly in children, and is followed by little or no opacity, but often by a small pit (facet).

Herpetic Ulcer results from a ruptured herpetic vesicle, and spreads superficially, involving more or less of the surface of the cornea.

Dendriform Ulcer (Dendriform Keratitis) is a rare and chronic form of superficial ulcer, which commences with a grayish line and spreads by sending out branches which present small knob-like extremities.

Catarrhal Ulcer is crescentic in form, marginal in situation, and complicates catarrhal conjunctivitis.

Abscess of the Cornea is the name given to a purulent infiltration, involving the substance of the cornea, but covered both superficially and posteriorly by sound corneal tissue. It is merely a stage of corneal ulceration.

Onyx is an obsolete term, which refers to the settling of

pus between the layers of the cornea, the occurrence of which is now believed to be extremely doubtful.

Treatment may be divided into (1) constitutional, (2) treatment of pre-existing local conditions, (3) local treatment of the ulcerative process.

Constitutional.—Since ulcers usually occur in persons in whom the general condition is below par, it is necessary to *improve the tone of the system* by attention to diet, fresh air, hygienic surroundings, condition of the bowels, etc., and often to administer tonics.

Treatment of Pre-existing Local Conditions.—Foreign bodies are to be removed and other local irritating conditions remedied. The various forms of *conjunctivitis and dacryocystitis* must receive careful attention.

Local Treatment includes atropine (sometimes eserine), bandage, hot compresses, antiseptic lotions, scraping, cauterization and paracentesis of the cornea, and division of the ulcer by Saemisch's method.

Atropine must be instilled in sufficient quantity to keep the pupil dilated; it acts favorably upon the ulcer by diminishing the iritis. One drop of a one-per-cent. solution may be used three times a day or oftener. When the ulcer is central, the iris is drawn away from the seat of perforation, and there is less danger of adhesion or prolapse. When the ulcer is *peripheral and deep*, so that a perforation is imminent, *eserine* (one-third of one per cent.) may be substituted, for the same reasons.

Bandaging keeps the lids closed, and the eye at rest, and shuts out dust and other irritating agents. When the ulcer is superficial, a light application (protective bandage) is indicated; when there is danger of perforation, a firm bandage (*pressure bandage*) is applied. When there is considerable secretion from the conjunctiva or lachrymal sac, the bandage must be left off.

Hot compresses should be applied for half an hour at a time, several times a day; they favor healing of the ulcer.

Antiseptic lotions such as solutions of boric acid, sodium chloride, bichloride of mercury (1:6,000), act as cleansing agents, and are especially useful when there is much discharge.

Other measures are sometimes resorted to: Iodoform sprinkled upon the cornea or applied in the form of an ointment, subconjunctival injections of corrosive sublimate (1:5,000), protargol (two per cent.), formalin (1:2,000).

To limit spreading: If these remedies are insufficient and the ulcer spreads, we must destroy the infective focus either by *scraping* the floor and margins of the ulcer with a small, sharp spoon or curette, or, better, by *cauterizing* this area.

Cauterization is effected by tincture of iodine, the stick of nitrate of silver, and by the actual cautery or the galvano-cautery.

Tincture of Iodine offers a very efficient mode of disinfecting and cauterizing corneal ulcers. A piece of absorbent cotton is wound firmly upon an applicator, dipped into tincture of iodine and then exposed to the air for a few seconds so that there is no excess of liquid. It is now brushed upon the ulcer and its infiltrated margins. It is usually necessary to repeat the cauterization a number of times on successive days.

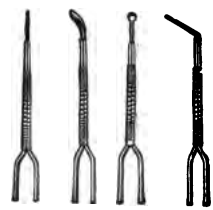


FIG. 73.—Eye Electrodes.

Galvano-Cautery.—After thorough anæsthesia of the eye, one of the electrodes shown in Fig. 73 is placed cold upon the part to be cauterized, the connection made so that the burner assumes a deep red color, and then the connection quickly broken. Successive points are cauterized in this manner, each for a very short period, so as to prevent perforation and the propagation of heat to deeper parts. In the absence of a galvano-cautery apparatus, the thermo-cautery or the actual cautery will an-

swer; a *platinum probe* fitted in a wooden handle is heated in the flame of an alcohol lamp; or a squint hook may be used for this purpose.

Paracentesis of the Cornea is another valuable measure. This puncture is frequently made with a paracentesis trocar, which is provided with a thick shoulder to prevent the instrument from penetrating too far (Fig. 74); it may be made with the lance-shaped knife (Figs. 101, 102), or with the Graefe cataract knife (Fig. 103). After local anæsthesia and fixation of the eyeball with the fixation forceps (Fig. 100), the instrument is passed perpendicularly through the cornea, near its lower margin, unless the situation of the ulcer requires another site. As soon as its point reaches the anterior chamber, the handle of the instrument is depressed and the knife or trocar is pushed on horizontally, avoiding injury to the iris or lens, until the incision is about 3 mm. long. Then it is withdrawn slowly with pressure upon the posterior lip of the wound, so as to evacuate the contents of the aqueous chamber gradually. It may be necessary to repeat the paracentesis or to reopen the wound with a probe daily until the ulcer cleanses itself.

FIG. 74.—Paracentesis Trocar.

Saemisch's Operation of splitting open the ulcer is indicated in severe forms of serpiginous ulcers. A Graefe knife is thrust through clear corneal tissue 1 or 2 mm. to the outer side of the ulcer, made to traverse the anterior chamber, and brought out 1 to 2 mm. to the inner side of the ulcer. The edge of the knife is directed forward and the ulcer is split through its centre and the hypopyon removed. The incision must be reopened with a probe daily, until the ulcer becomes clean.

After spontaneous perforation of an ulcer, atropine is instilled, a pressure bandage applied, and perfect rest insisted

upon. If there is a recent *prolapse* of the iris, the latter is freed from adhesion to the margins of the opening and then *excised;* this has the effect of an iridectomy. But if the prolapse has existed for some days it must be allowed to remain; subsequent operative interference may then be indicated.

After the healing process has become fairly initiated, certain mildly stimulating remedies, such as the ointment of the yellow oxide of mercury, are used to hasten cicatrization and to clear up the cornea as much as possible.

Keratitis from Defective Closure of the Lids.—This form of keratitis is due to *exposure of the cornea* when it remains uncovered by the lids (lagophthalmos). Under such circumstances it becomes desiccated, the conjunctival secretion and atmospheric dust settle upon it, infiltration and ulceration take place, with the subsequent course of ulcer of the cornea. The causes are paralysis of the orbicularis (facial paralysis), marked exophthalmos, and various deformities of the lids. Treatment consists in relieving the lagophthalmos if possible, frequent irrigation of the conjunctival sac with cleansing solutions, and closure of the lids by bandage or plaster. Unless the process has gone beyond certain limits it can be controlled by this plan of treatment.

Neuroparalytic Keratitis is a form of infiltration and ulceration of the cornea observed after paralysis of the *trigeminus*. The changes are considered by some to be trophic, by others to be due to exposure and lodgment of foreign substances upon the insensitive cornea. There is no pain or lachrymation, the course is chronic, and the result is considerable opacity of the cornea. Treatment consists in applying a bandage to the eye, or keeping the lids closed with plaster or suture; atropine and hot compresses may be of service.

Xerotic Keratitis (*Keratomalacia*) is the result of lack of nutrition of the cornea. It is a rare disease which occurs

in greatly debilitated children. The cornea corresponding to the palpebral aperture becomes cloudy, desiccated, covered with scales, and ulcerates and perforates. The great majority of such patients die from the disease which is responsible for the corneal condition. Treatment consists in measures to increase the general strength; locally, hot compresses, antiseptic lotions, bandaging, and atropine are indicated.

INTERSTITIAL OR PARENCHYMATOUS KERATITIS.

A *cellular infiltration* of the middle and posterior layers of the cornea occurring in *childhood*, *chronic* in its course, not leading to ulceration, but accompanied by more or less *inflammation of the uveal tract*.

Objective Symptoms.—The affection begins either in the centre or at the margin of the cornea. If it starts in the centre, this part will present a *grayish infiltration*, the superficial layers at first retaining their normal lustre; this central patch soon spreads so that the whole cornea becomes implicated. If it commences at the periphery, one or more grayish crescents are seen, which soon spread toward the centre and involve all the cornea. After the infiltration has become general, the cornea will become *softened*, of a dense *grayish* or sometimes yellowish-gray color, so that the iris can no longer be seen, and *vision is reduced* to little more than perception of light. The surface of the cornea is now *steamy* and resembles ground glass. At this period or even before, deep-seated blood-vessels (derived from the anterior ciliary) make their appearance and pervade more or less of the cornea; they cover either the periphery, circumscribed sectors, or the whole cornea. This *vascularization* gives rise to a dirty-red or yellowish-red discoloration, which is known as the *salmon-colored patch*. The progress thus far is accompanied by *irritative symptoms* and lasts one or two months.

The inflammation then begins to *subside*. The periphery of the cornea *clears up*, the blood-vessels become fewer, the irritative symptoms disappear, and *vision improves*. *Several months* or even a longer period is consumed in this process, the centre of the cornea being the last portion to clear. In favorable cases, after a year or more, nothing but a very faint, central opacity and evidences of a few minute peripheral vessels can be found.

Not all cases will, however, run such a benign course. The *anterior portion of the uveal tract is regularly involved*. In mild cases, this will consist merely in congestion of the iris. But in *more pronounced types*, there will be *iritis*, *chorioiditis*, *cyclitis*, and changes in the *vitreous;* in such cases, after the cornea has become less opaque, we may find evidences of these inflammations, in the form of adhesions of the iris to the lens (posterior synechiæ), changes in the iris and chorioid, opacities of the vitreous, and even occlusion of the pupil and iridocyclitis. Staphyloma of the cornea may also follow. So that *more or less serious impairment of sight* may ensue as a result of these inflammatory processes. Furthermore, the clearing-up process in the cornea may come to a standstill, leaving a *dense opacity* which also causes loss of useful vision.

Subjective Symptoms.—During the period of infiltration and vascularization there will be *photophobia*, *lachrymation*, *pain*, and *interference with vision*, the intensity usually depending upon the severity of the process; these symptoms gradually subside during the progress of absorption.

Both eyes are usually involved; frequently the inflammation in the second eye commences after that in the first has existed for some weeks or months.

Etiology.—The disease usually occurs *between the fifth and fifteenth years*, less commonly after this period, and rarely after thirty. The great majority of cases are due to *inherited syphilis;* in few instances it depends upon

acquired syphilis, tuberculosis, or occurs without known cause In many cases there will be other

Signs of Inherited Syphilis, such as characteristic physiognomy, peculiar conformation of the skull (square forehead, prominent frontal eminences, depressed bridge of nose), radiating scars at angles of mouth (Fig. 75), scars in the mouth and pharynx, ozæna, enlarged cervical lymphatic glands, nodes on the bones, and more or less impairment of hearing. The permanent *teeth* are ill-developed, their angles rounded off, and there is often a *crescentic notch* in the free margin; these changes are especially marked in the upper central incisor teeth (*Hutchinsonian teeth*, Fig. 75).

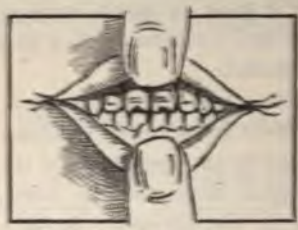


FIG. 75.—Notched Teeth Accompanying Parenchymatous Keratitis.

Treatment.—*Local: Atropine*, protection from light by *smoked coquilles* or by a shade, *hot compresses*. When the cornea begins to clear, we employ mild *stimulating ointments*, such as yellow oxide of mercury and calomel, often combined with gentle *massage*. We must be careful not to apply stimulating treatment too early.

Constitutional: Calomel, gr. $\frac{1}{10}$ four times a day, or *potassic iodide*, gr. v., combined with *corrosive sublimate*, gr. $\frac{1}{40}$, t.i.d. Syrup of the *iodide of iron* or other preparation of iodine, *cod-liver oil*, iron and quinine, and *attention to the general health*. In the rare cases occurring in adults, we prescribe mercury by inunction or by hypodermic injection, also iodide of potassium

Pannus (*Vasculo-nebulous or Vascular Keratitis*) has been described in connection with trachoma (p. 97).

UNCOMMON FORMS OF NON-SUPPURATIVE KERATITIS.

Vesicular Keratitis comprises a number of uncommon inflammations of the cornea, in which the distinguishing feature is the occurrence of groups of small clear *vesicles*, or of a single large transparent *blister*, with marked *irritative symptoms*. Vesicles occur in herpetic keratitis (herpes corneæ) and in the keratitis accompanying zoster corresponding to the distribution of the fifth nerve, bullæ in keratitis bullosa.

Keratitis Profunda is a form of deep-seated inflammation of the cornea occurring in adults, in which a gray, central opacity of the cornea develops, accompanied by irritative symptoms; it becomes entirely or almost perfectly absorbed in a few weeks, and requires treatment similar to that of interstitial keratitis.

Sclerosing Keratitis is the name given to the corneal complication of scleritis (p. 137). The portion of the cornea adjacent to the scleritic nodule participates in the process, and a triangular opacity remains. The symptoms and treatment correspond to those of scleritis.

Ribbon-shaped Keratitis (*Transverse Calcareous Film of the Cornea*) is a whitish or grayish band, which extends across the cornea opposite the palpebral aperture, and often contains lime. It occurs usually in old persons, and in eyes which have been seriously injured or lost by a previous intraocular affection. Treatment consists in gently scraping away the band and using solutions of sodium carbonate (gr. i. to ʒ i.).

A number of other forms of keratitis are described, but are of rare occurrence.

Punctate Keratitis (*Descemetitis*) is the name which was formerly given to dot-like deposits upon the posterior surface of the cornea which we now know to be part of the exudation in inflammations of the uveal tract (iritis, cy-

clitis, irido-cyclitis). This condition is never the result of an inflammation limited to the cornea. It usually shows upon the lower portion of Descemet's membrane, the area being triangular with the base at the margin and the apex near the centre of the cornea (Fig. 87). These deposits are usually absorbed.

Bulging of the Cornea is either of inflammatory origin, when it is known as *staphyloma*, or of non-inflammatory origin, when it is called *keratoconus*.

STAPHYLOMA OF THE CORNEA.

A *protrusion* of a previously inflamed cornea (Fig. 76), formed of more or less corneal tissue, iris, and cicatrix; very often the iris forms the chief part. It develops after corneal softening, ulceration, and perforation. It may be *total*, when it occupies the situation of the entire cornea, or *partial*, when it occupies only a portion of this area. In shape, it may be globular, conical, or lobulated. In color it is whitish with bluish areas representing spots where pigment shows through the thin cicatrix; it may be all white or all bluish. Some blood-vessels are frequently seen on the surface. It varies in size, being small in some cases and so large in others that the lids cannot close.

FIG. 76.—Staphyloma of the Cornea.

Symptoms.—Besides the objective signs just mentioned, there are changes in the eyeball, in the staphyloma, and in the lids. There is almost always *increased tension*, often due to obliteration of the pupil. This condition causes *pain*, produces *changes in the interior* of the eye (atrophy of the optic nerve, retina, and chorioid) which lead to *blindness*, results in an increase in the size of the bulging, and is responsible for staphyloma of the sclera. The conjunctiva

becomes the seat of inflammation from mechanical irritation. The summit of the protrusion becomes dry and ulcerated, and there is frequently *rupture* followed by closure of the opening; this process may be repeated a number of times, until the eye is lost and a *shrunken globe* remains.

Even before these scondary changes have taken place, there is considerable *deformity*, and *sight* is very much *reduced*. In total staphyloma there will be merely perception of light; in the partial form the amount of sight will depend upon the condition of the cornea which is preserved, the position of the pupil, and the extent to which the curvature of the cornea has become altered.

Treatment.—In *partial staphyloma*, an *iridectomy* should be performed (p. 184) for the purpose of reducing tension, flattening the protrusion and preventing its increase, and to serve for optical purposes. We select the part of the iris corresponding to the most clear portion of the cornea. If there is no anterior chamber and the iris lies against the posterior surface of the cornea, this operation is impossible. In such cases, we may *incise*, or *excise* a portion and unite with sutures, followed by a *pressure bandage* for a considerable period of time.

In *total staphyloma*, we resort to incision, abscission, or enucleation. *Incision* is followed by the extraction of the lens if it still be present. *Abscission* is performed by cutting through one-half of the protrusion with the knife, and separating the other half from the ring of corneal tissue forming its base with forceps and scissors; the lens is removed; the edges of the corneal gap are then brought together with sutures drawn through the corneal tissue, or better, through the conjunctiva which has previously been freed around the limbus. *Enucleation*, or one of its substitutes, is practised in certain cases in which the staphyloma is very large, or in which for various reasons abscission is not advisable.

KERATOCONUS OR CONICAL CORNEA.

A non-inflammatory *conical protrusion* of the centre of the cornea (Fig. 77), due to thinning in this situation and to the effects of intraocular pressure. The condition is *not* of *frequent* occurrence and is usually observed in *young women*. It is easily seen when well marked; when less developed, it is recognized by the annular shadow produced when the eye is examined with the ophthalmoscope at a distance, by the *alteration in shape of the image* when Placido's disc is used, and by *distortion* of the picture of the fundus as seen with the ophthalmoscope. The condition tends to progress for many years before it comes to a standstill. When pronounced, it often presents a *slight opacity* at its apex; it never ulcerates. Conical cornea causes *myopia and astigmatism* and seriously *interferes with sight*, especially peripheral vision, even after the best possible correction with glasses. *Treatment* consists in providing concave sphero-cylinders, repeated paracentesis followed by the long-continued application of a pressure bandage, pilocarpine or eserine to diminish tension, and abscission or *cauterization of the apex* of the cone to cause flattening by subsequent cicatrization.

Fig. 77.—Keratoconus.

Fig. 78. — Knapp's Corneal Electrode for Keratoconus.

Cauterization is used most frequently and is the most successful; it is generally followed by an iridectomy, for the purpose of bringing the pupil opposite clear cornea. The electrode used for this operation (Fig.

78) has a spherical tip with which the apex of the cone is cauterized as deeply as Descemet's membrane, or even with perforation.

OPACITIES OF THE CORNEA.

This term refers to a lack of transparency of the cornea resulting from inflammation, ulceration, or injury. According to density, the corneal opacity is called *nebula*, when faint and cloud-like, often overlooked until examined by oblique illumination; *macula*, when more pronounced and appreciable as a gray spot in daylight; *leucoma*, when dense and white (Fig. 79). When the iris is attached to the scar tissue, the condition is spoken of as *adherent leucoma*.

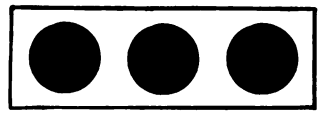


FIG. 79.—Opacities of the Cornea: Nebula, Macula, Leucoma.

Opacities of the cornea interfere with perfect vision when they involve or encroach upon the pupillary area, the degree depending upon their density. Even slight opacities cause considerable *visual disturbance* on account of the resulting diffusion of light. Denser opacities cause *disfigurement*.

Treatment.—Various measures are used to reduce the density of corneal opacities, or, if faint, to cause their disappearance. Such remedies are of value only when the opacity is *recent* (not older than a year or two); they act most successfully in children and when the change is superficial. Most commonly the *ointment of the yellow oxide of mercury* is placed in the conjunctival sac, after which the cornea is *massaged* for a few minutes, and then *hot compresses* are applied. Diluted tincture of opium, turpentine, and other *irritants* are used for this purpose. *Electricity* has been of service.

When such measures are unsuccessful, an iridectomy for

artificial pupil may be performed, the coloboma being made opposite a clear part of the cornea.

To remove the disfigurement in cases of leucoma, *tattooing* is often resorted to. The eye is anæsthetized, and the leucoma covered with a thick paste of India ink; the pigment is then introduced obliquely into the corneal substance, either by means of an instrument consisting of a row or bundle of round needles (Fig. 80) or with a grooved needle (Fig. 81). The color fades in the course of a few years and then the operation may be repeated. When the opacity covers only a part of the pupillary area, tattooing is useful in preventing the diffusion of light which is so annoying to the patient. The operation is contraindicated when the cornea is very thin or when it is likely to increase intraocular disease by irritation.

FIG. 80.—Tyson Tattooing-Needles.

FIG. 81.—Grooved Tattooing-Needle.

INJURIES OF THE CORNEA.

These comprise foreign bodies, burns, and wounds.

Foreign bodies, consisting of iron, coal, ashes, dust, etc., frequently adhere or become embedded in the cornea, causing much pain, lachrymation, and photophobia. When the foreign body is small, it may be difficult to detect, unless we make use of *oblique illumination*. The mischief which a foreign body provokes depends upon the *depth* to which it penetrates and whether or not it is *infected*. If present for a number of days, a surrounding area of *infiltration* appears, resulting in a small ulcer, and in this manner the foreign body may become dislodged; if it consists of iron or steel, this ring will become stained by rust. Foreign bodies are the most common causes of *ulcers* of the cornea.

To Remove a Foreign Body.—The eye is cocainized; the

patient is seated facing a good light with the surgeon standing behind and supporting the head; the lids are separated and the eyeball is steadied by the fingers of the left hand, the index finger is applied to the margin of the upper lid and the middle finger to the lower lid, and the two fingers are separated, at the same time gently pressing backward (Fig. 82). The instruments used are either the *blunt spud*, the *gouge*, or the *foreign-body needle*. When the foreign body is superficial, the blunt spud will answer (Fig. 83). When it has penetrated into the corneal substance, it must be *picked* or dug out with the gouge (Fig. 84), or the needle (Fig. 85); in such cases, the instrument is passed *behind* the foreign body. The wound which results must be kept *clean* by frequent irrigation with solution of boric acid; frequently a protective bandage is indicated. If a ring of rust is present, this also should be removed. Care must be taken to inflict as little injury as possible, and when the foreign body is deep, not to perforate the cornea. If it penetrates into the anterior chamber, a keratome (Fig. 101) should first be passed through the cornea and behind the foreign body, so that the latter will not be pushed into this space during efforts at removal.

FIG. 82.—Method of Removing a Foreign Body from the Cornea.

FIG. 83.—Foreign-Body Spud.

FIG. 84.—Foreign-Body Gouge.

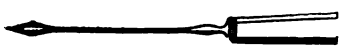


FIG. 85.—Foreign-Body Needle.

Burns of the cornea are treated like similar conditions of the conjunctiva (p. 111).

Wounds may be non-penetrating or penetrating. *Non-penetrating* wounds are most commonly abrasions due to

scratching with the finger nail, twig of a tree, or the like. Such injuries, though very painful, heal readily unless infected; they should be kept clean by frequent *irrigation* with solution of boric acid; a *bandage* may be indicated, and sometimes *atropine.*

Perforating wounds are more serious owing to the danger of prolapse of the iris and injury to the deeper parts. They should be treated by thorough *cleansing, atropine or eserine* according as they are central or peripheral, and a *pressure bandage.* If extensive, the edges may be stitched together.

CHAPTER IX.

DISEASES OF THE SCLERA.

Anatomy.—The sclerotic coat (sclera) is the tunic which with the cornea forms the external fibrous layer of the eyeball; it is *strong, opaque,* and *inelastic,* and serves to maintain the *form* of the globe. Its thickness is about 1 mm., but varies at different points. Its structure resembles that of the cornea, being composed of bundles of connective tissue with some elastic fibres, disposed in both longitudinal and transverse layers; these are connected by cement substance containing cell spaces in which are lodged connective-tissue corpuscles; these parts are, however, much less regularly arranged than in the cornea. In the child, the sclera often has a bluish-white color, owing to its being thinner and allowing the dark pigment of the chorioid to show through. The sclera is pierced about 2.5 mm. internal to the posterior pole of the eye by the optic nerve; here it has blended with it the external fibrous sheath of the nerve. The part through which the nerve passes is known as the *lamina cribrosa.*

The outer surface of the sclera is *white and smooth,* covered by *Tenon's capsule* and the conjunctiva, to which it is joined by *loose connective tissue* (*episcleral*); in front, it presents the insertions of the extrinsic muscles of the eyeball. Its inner surface is brown and rough, being covered by delicate, pigmented connective tissue, which is united to the chorioid by filaments traversing the lymph space existing between the sclera and chorioid; where it is pierced by vessels and nerves, a communication between the cav-

sule of Tenon and the suprachorioidea is established. Though traversed by many blood-vessels, the sclera itself has a very scant vascular supply; but the episcleral tissue contains numerous vessels.

Affections of the sclera include superficial inflammation (episcleritis), deep inflammation (scleritis), staphyloma, and injuries.

Inflammation of the Sclera (*Scleritis*) may be either *superficial or deep*. The *superficial* form, called *episcleritis*, is limited to the tissues superficial to the sclera and is relatively harmless. The *deep* form, known as *scleritis*, involves the sclera itself and extends to subjacent and contiguous parts, causing serious consequences. There is often an absence of a very sharp line of division between the two forms.

EPISCLERITIS.

An inflammation of the *subconjunctival connective tissue*.

Symptoms.—There are some *discomfort*, *lachrymation*, slight pain, and *photophobia*. A flat or somewhat raised inflammatory *patch of a purple color* is seen adjacent to the cornea or a short distance from the limbus. There is no tendency to suppuration or ulceration. After a few weeks, the purple spot will disappear; but others are apt to take its place; in this way the process may *encircle the cornea*. Owing to this tendency to *relapses*, the disease often lasts *many months*. Sometimes some discoloration of the sclera remains, but there is no interference with vision. Occasionally the adjacent portion of the cornea is implicated. The disease may resemble a marked case of *phlyctenular conjunctivitis*; it may merge gradually into *scleritis*.

Etiology.—It is usually observed in *adults*, especially in women. It is often found in *rheumatic and gouty* individuals. Syphilis, tuberculosis, and menstrual disorders are predisposing factors.

Treatment should be of a *sedative nature: Warm fomen-*

tations, leeches to the temple, and gentle *massage;* if photophobia be pronounced, smoked coquilles. *Subconjunctival injections of* bichloride of mercury (1:5,000) have recently been recommended. The *ointment of the yellow oxide of mercury* is often of value. When there is a rheumatic history, *sodium salicylate* in large doses (gr x. to xv. every two hours) should be given. Other constitutional disorders should be prescribed for. *Iodide of potassium* may be ordered, also hypodermic injections of pilocarpine.

SCLERITIS.

An inflammation of the sclera, in which the symptoms are *acute*, the course is *prolonged*, and the consequences are *serious*. In this disease the *sclera itself* is involved in the inflammatory process; it becomes *softened*, thinned, and bulging, and *staphyloma* results. Both eyes are frequently involved. *Relapses* are very common.

Symptoms.—*Pain*, usually severe, and frequently radiating to neighboring regions, *tenderness* over the ciliary region, *lachrymation*, and *photophobia*. The *tension* of the eyeball is frequently *increased;* secondary *glaucoma* often ensues.

There are well-marked dusky or *violet patches* adjacent to the cornea, often extending to the equator, and frequently surrounding the limbus.

Complications.—The *cornea* is frequently implicated and ulceration and opacity follow. Not uncommonly there are *iritis*, cyclitis, chorioiditis, opacities of the vitreous, and secondary glaucoma; the combination of such complications is known as *anterior uveitis*. As a result of these changes, *vision* is often *seriously interfered with* and sometimes lost. The thinning of the sclera results in *staphyloma* of the anterior portion of the globe, which presents a bluish appearance, and causes myopia.

Etiology.—The disease is most common in *adults*, and

especially in women. *Rheumatism and gout*, syphilis, tuberculosis, and disorders of menstruation are predisposing factors. *Exposure to cold* is sometimes the exciting cause.

Treatment comprises the measures advocated in episcleritis, energetically applied. The eyes must obtain complete *rest* *Atropine* is often indicated for the complications. After the acute symptoms have subsided, an *iridectomy* is sometimes advisable for diminishing glaucomatous tension or reducing the staphyloma

STAPHYLOMA OF THE SCLERA.

A *thinning and bulging* of the sclerotic occurring either at the *anterior* portion, the *equator*, or the *posterior* portion of the eyeball.

Anterior and equatorial staphylomata are usually secondary to inflammations of the uveal tract and sclera which have caused increased tension. They present a bluish-gray bulging which may be limited or may extend all around the cornea. This bulging shows a tendency to increase; occasionally it bursts. *Iridectomy*, if feasible, is the only treatment, and is done for the purpose of arresting the process. In some cases, when the enlarged eyeball causes much discomfort and is sightless, *enucleation* or evisceration is advisable.

Posterior staphyloma is of common occurrence and is generally associated with myopia and chorioiditis (p. 158). It is seen with the ophthalmoscope, presenting a white crescentic or irregular patch which embraces the temporal side of the optic disc (Fig 91, Plate III.).

INJURIES OF THE SCLERA.

The important injuries include *rupture* and *perforating wounds;* these are serious on account of the danger of escape of the contents of the eyeball and infection of the interior.

Small, clean, perforating wounds often heal without reaction, and require no other treatment than *cleansing* and the application of a *bandage*.

Large, gaping wounds and ruptures frequently allow *escape of the vitreous*. There will be blood in the vitreous, diminished tension, and some of the underlying tissues (chorioid, ciliary body, or iris) varying with the position, will be found in the wound. Such wounds should be *cleansed*, the *prolapsed parts returned* when not too seriously injured, and the *opening closed* by sutures in the sclera or preferably through the conjunctiva; the patient must remain absolutely *quiet* and the eye should be *bandaged*.

Sometimes such wounds fail to excite much inflammatory reaction; then they heal quite readily, often with incarceration of the prolapsed parts in the scar. But frequently they give rise to *panophthalmitis* with ultimate phthisis bulbi, or to plastic *iridocyclitis* with loss of sight. When the wound involves the ciliary body, iridocyclitis is apt to be set up, and the injury becomes more dangerous on account of the liability of such wounds to excite *sympathetic ophthalmia*.

Ruptures of the sclera are produced by blows and blunt instruments; they usually occur near the corneal margin, generally above. The conjunctiva may not be broken.

When injuries of the sclerotic are very extensive and cause considerable loss of contents of the eyeball, and when we believe that useful sight cannot be hoped for, the *eyeball* should be *removed at once*. This becomes still more urgent when the wound involves the dangerous zone, *the ciliary region*.

The presence of a *foreign body* is a serious complication. The attempt should be made to extract the foreign body, as described on p. 133.

CHAPTER X.

DISEASES OF THE IRIS.

Anatomy and Physiology.—The second or *vascular* coat of the eye (*uvea or uveal tract*) lies immediately beneath the sclera; it provides for the *nourishment* of the eyeball, and it is formed of three parts, which from before backward are known as the *iris*, the *ciliary body*, and the *chorioid*. These three portions are so *intimately associated* that when one part becomes diseased, the others frequently participate.

The Iris is a *colored membrane*, circular in form, hanging behind the cornea immediately in front of the lens, and perforated in its centre by an aperture of variable size, the *pupil;* it serves to *regulate the amount of light* admitted to the interior of the eye, and cuts off the marginal rays which would interfere with the sharpness of the retinal image. Its peripheral border springs from the head of the ciliary body and the ligamentum pectinatum. Its free inner edge, the boundary of the pupil, lies upon the anterior capsule of the lens when the pupil is contracted or moderately dilated; with maximum dilatation of the pupil it hangs free in the anterior chamber. The iris separates the *anterior* from the *posterior chamber* of the eyeball. Its anterior surface presents great *variation in color* in different eyes, and is marked by radially directed, wavy lines, converging toward the circle of irregular elevations and small depressions (crypts) situated near the pupil; other finer lines are seen extending from this ring to the pupil. This appearance is produced by the subjacent *blood-vessels.*

In *structure*, the iris consists of a delicate, spongy connective-tissue stroma, containing branched pigmented cells, muscular fibres, and an abundance of vessels and nerves; it is covered anteriorly by endothelium, and posteriorly by the posterior limiting membrane and the retinal pigment layers.

The *color* of the iris depends partly upon the pigment in the stroma cells, which is variable, and partly on that in the cells of the retinal layers, which is constant.

The muscular tissue, the *sphincter pupillæ*, is a narrow band, about one millimetre wide, situated close to and encircling the pupil posteriorly, and supplied by the *third nerve*. The *posterior limiting membrane* consists of fibres which extend from the ciliary to the pupillary margin, which are regarded by some authorities as consisting of unstriped muscle fibres and as contributing to the active dilatation of the pupil. The chief factor in active *dilatation of the pupil* is, however, the contraction of the *thick muscular coats of the arteries*, under the control of the *sympathetic*.

The *posterior surface* of the iris is covered by two strata of pigmented cells, the uveal layer, which extends to the free border around which it turns a little, forming the black fringe of the pupillary margin.

The *vessels* of the iris come from the two branches of the ophthalmic known as the long posterior ciliary arteries; each artery divides into an upper and a lower branch; these anastomose with the corresponding vessels of the opposite side and with the anterior ciliary, and form a vascular ring just behind the attached margin of the iris, the *greater vascular circle of the iris*. This gives off branches to the ciliary body and iris; the iris branches converge towards the pupil and here form by anastomosis a smaller vascular circle, the *lesser vascular circle of the iris*. The veins of the iris follow the arrangement of arteries just described; in addition they communicate with the canal of

Schlemm; they chiefly pass backward to the venæ vorticosæ.

The *nerves* are given off from the plexus in the ciliary body, and are derived from the third, the nasal branch of the ophthalmic, and the sympathetic.

Pupillary Membrane.—In the fœtus the pupil is closed by a thin, transparent, delicate membrane—the pupillary membrane. The membrane and its vessels are gradually absorbed in the seventh or eighth month of fœtal life. A few shreds may remain at birth; occasionally part or all of the membrane persists (*persistent pupillary membrane*).

IRITIS.

An *inflammation of the iris* which may be divided into the following

Varieties: (1) According to its *course*, into *Acute*, *Subacute*, *and Chronic.*

(2) According to the *pathological products*, into *Plastic*, *Serous*, *Purulent*, *and Tuberculous.*

(3) According to its *etiology*, into *Syphilitic*, *Rheumatic*, Gouty, Diabetic, *Gonorrhœal*, *Tuberculous*, Scrofulous, Traumatic, Sympathetic, Secondary, and *Idiopathic.*

The classification according to the nature of the pathological products is unsatisfactory because one type merges into the other. It is better, therefore, to consider *Iritis In General*, and then to mention the peculiarities of the different forms which have been named according to their etiology.

Objective Symptoms.—The *iris* looked *altered.* It appears *swollen*, *dull*, *loses its lustre*, its markings become *indistinct*, its *color changes* and becomes greenish in blue or gray irides, and muddy in darker varieties. These changes are due to *congestion* of the iris and *exudat* cells and fibrin into its substance; also to exudation the anterior chamber.

The *pupil* is *contracted*, *grayish*, *sluggish* in action, and *irregular* (Fig. 86); the last peculiarity is due to *adhesions* between the posterior surface of the iris and the anterior capsule of the lens (*posterior synechiæ*), best seen after the instillation of atropine.

The contents of the *aqueous chamber* show changes; there is frequently *turbidity;* there may be more or less dust-like *deposit on Descemet's membrane* (so-called *keratitis punctata*), which often involves the lower part (Fig. 87) or may

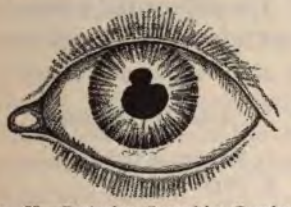


FIG. 86.—Posterior Synechiæ Causing Irregular Pupil in Iritis.

FIG. 87.—Deposits on Descemet's Membrane in Iritis and Iridocyclitis; so-called Keratitis Punctata.

give a cloudy appearance to the entire cornea. In this exudation there may be considerable *pus* which then gravitates to the bottom (*hypopyon*) or considerable *fibrin*, which coagulates into a grayish mass (*spongy iritis*), or there may be blood (hyphæma). The *anterior chamber* may be *deeper* than normal. The tension of the eyeball, though usually normal, may be increased.

The *anterior capsule* of the lens may present evidences of exudation, and also small *spots of uveal pigment* where posterior synechiæ have been torn away.

There is always marked *circumcorneal injection*, and with this pink zone there is more or less conjunctival congestion.

Subjective Symptoms consist of *pain*, *photophobia*, *lachrymation*, *interference with vision*, and sometimes general malaise.

The *pain* is often severe, *neuralgic* in character, *radiating* to the forehead and temple, and worse at night. It is

sometimes accompanied by *tenderness* of the eyeball, a symptom pointing to involvement of the ciliary body

The diminution in the acuteness of vision depends upon the cloudiness of the anterior chamber and the deposits in the pupil and upon Descemet's membrane. When very marked, it indicates extension of the inflammation to the *deeper parts*.

Differential Diagnosis.—Iritis is most frequently mistaken for *acute catarrhal conjunctivitis*. Sometimes *acute glaucoma* is mistaken for iritis. The differential points between iritis and conjunctivitis are given in the following tables:

Acute Iritis.	*Acute Conjunctivitis.*
1. Discolored and altered iris.	1. No change in iris.
2. Pupil small, gray, sluggish, irregular after use of atropine.	2. Pupil normal.
3. Exudation in anterior chamber.	3. Anterior chamber normal.
4. Ciliary (circumcorneal) injection; pink zone of fine vessels surrounding cornea and fading toward fornix.	4. Conjunctival injection, coarse meshes, most pronounced in fornix and fading toward the cornea.
5. Lachrymation, but no secretion.	5. Mucous or muco-purulent secretion.
6. Pain, worse at night.	6. Discomfort, but no real pain.
7. Conjunctiva usually transparent.	7. Conjunctiva reddened and opaque.
8. Vision diminished in acuteness.	8. No interference with vision.

Course.—Iritis may be *acute* and run its course in *several weeks;* or it may be *chronic* and last a number of *months*. A great *many cases terminate favorably*, especially when subjected to proper treatment early; the exudation becomes absorbed, and the iris returns to a normal condition with no evidences or mere traces of former inflammation Chronic cases present very mild inflammatory symptoms

or the latter may be entirely absent. Certain forms of iritis have a tendency to *recur*. Iritis may involve *one or both eyes;* when both eyes are attacked, the second usually is affected a short time after the first.

Complications.—The *neighboring parts of the eye* are sometimes involved in *severe forms* of iritis: conjunctiva, cornea, ciliary body, chorioid, vitreous, optic nerve, and retina. The association of inflammation of the ciliary body (*cyclitis*) with iritis (*iridocyclitis*) is so *common*, that some authors describe the two conditions together and regard pure iritis as rare. The following symptoms, occurring in the course of an iritis, point to the *existence of cyclitis:* Violent inflammatory symptoms, marked diminution in vision, tenderness in the ciliary region, deposits upon the posterior surface of the cornea, and increase or decrease of normal tension.

Sequelæ.—These are often *posterior synechiæ* and deposits upon the anterior lens capsule; less frequently there are exclusion of the pupil, occlusion of the pupil, atrophy of the iris, opacities of the vitreous, deposits upon the posterior capsule of the lens, and cataract. In *exclusion of the pupil* (annular posterior synechia), the iris is bound down throughout its entire pupillary margin, the pupil remaining clear; this causes a loss of comunication between the anterior and the posterior chamber; the aqueous secreted by the ciliary processes is hemmed in, the iris stretched (*iris bombé*) and atrophied, *glaucoma* results, and if unrelieved, blindness follows.

Etiology.—Iritis may be *primary*, or may be *secondary* to affections of neighboring structures. Primary iritis is frequently dependent upon some *constitutional disease:* very often *syphilis* and *rheumatism;* much less frequently, gout, tuberculosis, scrofula, gonorrhœa, acute infectious diseases, and diabetes. It may also be traumatic, sympathetic, and often is *idiopathic.*

Treatment.—(1) Atropine, (2) leeches, (3) hot fomenta-

tions, (4) rest, (5) protection from light, (6) treatment of etiological factor.

Atropine diminishes the congestion of the iris, puts this part at rest, causes mydriasis, and thus prevents adhesions and tends to break up those which have already formed. It should be instilled every two hours at first, and after the pupil is dilated, three or four times a day. When the inflammation is pronounced, the pupil will not dilate rapidly. The action of atropine is often increased by the addition of cocaine. In certain cases, symptoms of *atropine poisoning* occur, either local or constitutional, necessitating the substitution of some other mydriatic; a solution of the aqueous extract of belladonna (1:8) often acts well in such cases. Sometimes atropine causes an increase in inflammatory symptoms and must be stopped; then a *myotic* may be of service; this action is apt to occur when there is increased tension, and sometimes when there is a complicating cyclitis.

Two or three *leeches* applied to the temple, or the abstraction of an ounce of blood from this region by means of the artificial leech, usually have a favorable effect.

Moist, warm compresses for several hours each day diminish the pain and the inflammation. In traumatic iritis, iced compresses may be used.

Absolute rest in bed is indicated in the early stage of acute iritis and is an important aid in treatment.

Protection from light, by means of smoked coquilles or a shaded room, is essential.

Other important indications are light diet, abstinence from alcoholics, relief of constipation, and avoidance of all use of the eyes for near work.

Constitutional Treatment must meet the indications in the different forms. In *syphilitic* iritis *mercury* is given, usually by inunction, up to the point of salivation; after the acute symptoms have subsided, *mixed treatment* (mer-

cury and iodide of potassium) is substituted In certain apparently idiopathic forms, small doses of mercury have a favorable effect. In *rheumatic* cases we prescribe large doses of *salicylate of sodium;* this remedy also has a quieting effect upon the pain in other forms.

Paracentesis is occasionally resorted to for the purpose of relieving tension, and also in obstinate cases to produce a favorable effect upon the progress of the disease. *Iridectomy* is sometimes performed for the same reasons. As a rule, however, operative procedures are useful only after the inflammatory symptoms have subsided, for the purpose of remedying sequelæ.

It remains to consider briefly the distinctive features of certain varieties of iritis.

Clinical Varieties.—*Syphilitic Iritis* is the most *common* form. It occurs in the *secondary* stage of acquired syphilis; it is usually *acute;* the second eye is apt to become involved at a varying interval after the first one has become affected; there is more or less *plastic* exudation; in some cases there are yellowish, vascular *nodules* at the pupillary border of the iris (Fig. 88) — this is then pathognomonic; *pain is not pronounced;* if properly treated, relapses are not common.

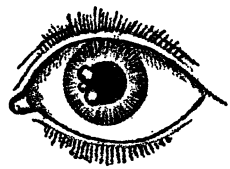


FIG. 88.—Syphilitic Iritis with Specific Nodules.

Rheumatic Iritis is usually *acute;* it frequently attacks *only one eye;* it occurs especially in adults; the effusion is *serous* with a few cells; *pain is pronounced; relapses are common.*

Gonorrhœal Iritis is occasionally seen in persons suffering from gonorrhœa or gleet; it resembles *rheumatic* iritis.

Idiopathic Iritis is the name given to a great number of cases in which we can find no cause; it occurs usually in adults, and generally attacks one eye.

Suppurative Iritis presents *hypopyon;* it is often *trau-*

matic; if *infected*, the process is merely part of a *panophthalmitis.*

Tuberculous Iritis is rather rare. It occurs in *young persons*, is apt to be *subacute* in course, *obstinate*, and presents *tuberculous nodules* near the attached border of the iris. There are often *constitutional* manifestations of *tuberculosis*, though sometimes there are no demonstrable signs of implication of other parts of the body.

TUMORS OF THE IRIS.

These may be (1) *inflammatory: a*, syphilitic, *b*, tuberculous, both of which have just been described; and (2) *new growths:* cysts, melanoma, and sarcoma, all of which are rare.

INJURIES OF THE IRIS.

These may be (1) non-perforating and (2) perforating.

(1) *Non-perforating injuries* (concussion, blows upon the eyeball) may cause (a) *mydriasis*, (b) a *tear* in the pupillary margin, in both of these cases eserine being indicated; (c) *iridodialysis*, a separation of the ciliary border of the iris, for which atropine is required.

(2) *Perforating injuries* are usually complicated by wounds of the lens and other parts of the eye. A perforating wound of the eyeball may lacerate the iris or merely allow the latter to project through a wound of the cornea or of the ciliary region (*prolapse*). In cases of prolapse, the wound must be irrigated with a mild cleansing lotion, such as boric acid or weak bichloride; if seen early, within a few hours, and there is no injury to iris and lens, the iris may be returned into the anterior chamber, atropine or eserine used according to the seat of the perforation, and a bandage applied. If there is little hope of saving the prolapsed portion of the iris, it should be excised, the cut edges carefully separated from the wound by a spatula,

atropine or eserine used according to the seat of the injury, and the eye bandaged.

OPERATIONS UPON THE IRIS.

Iridectomy is the only important operation upon the iris. It is described with glaucoma, which forms its most frequent indication..

Iridotomy and *Iridocystectomy* are operations the indications for which occur very infrequently, when after loss of the lens following injury or cataract operation, the pupil has been closed by inflammation or been drawn toward the cicatrix. In *iridotomy*, the iris fibres are cut transversely with a Graefe knife or with special forceps-scissors introduced through a small corneal incision. In *iridocystectomy*, an incision is made through the cornea, and the capsule and the edge of the iris are drawn out by means of a blunt hook or forceps, and cut off. The object of both operations is the formation of an *artificial pupil.*

THE PUPIL.

The normal pupil is circular and regular in outline. It is larger in the young than in advanced life. Its size should equal that of its fellow; both should respond alike when one is subjected to a change in intensity of illumination. The movements of the pupil are *contraction* and *dilatation.*

The contracting fibres of the iris, the *sphincter pupillæ* (muscle), are supplied by the *third nerve.* The dilating fibres in the posterior limiting membrane are supposed to be supplied by the *sympathetic.* The *blood-vessels of the iris,* also supplied by the sympathetic, constitute the principal agents in active *dilatation of the pupil;* contraction of these vessels causes narrowing of the iris with dilatation of the pupil.

Contraction of the pupil is effected by stimulation of the oculomotor nerve and by paralysis of the sympathetic. *Dilatation* follows paralysis of the third nerve or stimulation of the sympathetic.

The oculomotor-nerve fibres are conveyed through the ciliary ganglion and short ciliary nerves. The nucleus of origin of the third nerve concerned in the movements of the iris is in the floor of the aqueduct of Sylvius, and can be divided into three portions: (1) that giving rise to the sphincter fibres of the *iris*, (2) *accommodation* (ciliary muscle), and (3) convergence (*internal rectus*). The *sympathetic or dilating fibres* are given off from the cilio-spinal centre of the lower cervical spinal cord.

The pupil contracts upon exposure to light, with accommodation, and with convergence. The light contraction may be *direct* or *consensual*. The *direct light reflex* is obtained by exposing one eye to increased illumination and observing the contraction of the pupil of this eye. The *consensual or indirect light reflex* is obtained by throwing light into one eye and observing the contraction of the pupil of the other eye. The *accommodation* and *convergence reflex* is obtained by directing the patient to look at an object held several inches in front of the face in the middle line; the pupils will be seen to contract. These three actions are *associated*.

The *dilatation reflexes* of the pupil are seen upon shading the eye (both direct and consensual), and upon looking at a distant object. In addition there is a *sensory reflex*: when sensory nerves are stimulated, as by scratching or tickling the skin, both pupils dilate.

The *consensual contraction* is explained by the fact that the light stimulus in one eye is carried by the optic nerve and passes to *both* optic tracts, and in this way to the nucleus of the third nerve of each side (Fig. 89). Blindness in one eye abolishes the direct reflex in this eye, but its consensual reflex is preserved.

In certain pathological conditions, there may be loss of light reflex, without interference with sight. The *Argyll-Robertson pupil*, so frequently a symptom of locomotor ataxia, contracts with accommodation and convergence, but does not respond to light; it is usually accompanied by myosis. The characteristics of the pupils —size, equality, and reflexes, are of great value in the diagnosis of various affections of the nervous system and in the localization of cerebral lesions. Hence it is important to be familiar with the afferent and efferent routes which control the movements of the pupil (Fig. 89). *The course of the afferent impulse* is retina, optic nerve, both optic tracts, corpora quadrigemina, nuclei of origin of the third nerve in the floor of aqueduct of Sylvius (there being a communication between the two sides).

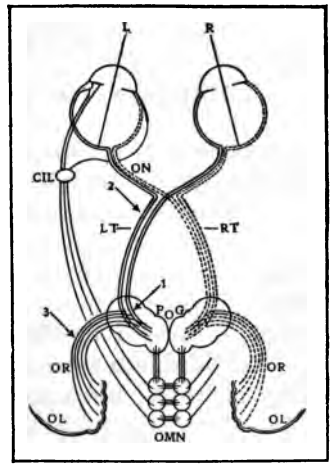


FIG. 89.—Visual and Pupillary Reflex Paths. *L*, Left eye; *R*, right eye; *ON*, optic nerve; *LT*, left optic tract; *RT*, right optic tract; *POG*, primary optic ganglia; *OMN*, oculomotor nuclei; *OR*, optic radiations; *OL*, occipital lobe; *CIL*, ciliary ganglion. Division of the fibres at 1 abolishes the reaction of the pupil to light upon illuminating the left half of either retina. At 2, the same result with right homonymous hemiopia. At 3 right homonymous hemiopia with preservation of the reaction of the pupil to light.

The efferent impulse travels on either side from these nuclei to the third nerve, the ciliary ganglion, short ciliary nerves, to the iris.

Mydriatics and myotics are described in the chapter on Ocular Therapeutics, and on p. 328. The *hemiopic pupillary reflex* is explained on p. 262.

CHAPTER XI.

DISEASES OF THE CILIARY BODY.

Anatomy.—The ciliary body is that part of the tunica vasculosa which extends backward from the base of the iris to the anterior part of the chorioid; it consists of the *ciliary processes* and of the *ciliary muscle.* A longitudinal section is of *triangular shape,* with a narrow base directed forward giving origin to the iris. The outer side of the triangle is formed by the ciliary muscle; the inner side can be divided into two parts: an anterior, which bears the ciliary processes, and a posterior portion, which is smooth.

The ciliary muscle (the muscle of *accommodation*) consists of non-striated muscular fibres arranged in bundles, anastomosing with one another frequently so as to form a sort of plexus, and running in three different directions—meridional, radiating, and annular. The proportion between circular and longitudinal fibres varies according to the refractive condition of the eye; the circular set is well developed in hyperopia (Fig. 190), but atrophied in myopia (Fig. 191). When the ciliary muscle contracts, it draws the ciliary processes and chorioid forward and inward, thus relaxing the suspensory ligament and allowing the lens to become more convex.

The ciliary processes consist of about seventy folds or thickenings, arranged meridionally, so as to form a circle. They have the same structure as the rest of the chorioid, but are even more vascular. They serve to *secrete the nutrient fluids* in the interior of the eye which nourish neighboring parts, especially the cornea, lens, and part of the vitreous. The inner surface of the ciliary body is covered

by three layers: externally, a homogeneous membrane continuous with the posterior limiting membrane of the iris; next, pigment epithelium; internally, next to the vitreous, a layer of cylindrical non-pigmented cells.

The ciliary body is supplied by branches from the greater circle of the iris and by the anterior ciliary *arteries.* The *veins,* constituting the greater part of the ciliary processes, pass backward to the venæ vorticosæ of the chorioid. A part of the veins from the ciliary muscle pass backward, pierce the sclera, and run beneath the conjunctiva with the anterior ciliary arteries. These constitute the violet subconjunctival vessels seen running backward in ciliary injection and in deeper congestion (glaucoma). They anastomose with the conjunctival veins, and communicate with Schlemm's canal.

CYCLITIS.

As already pointed out, iritis is frequently associated with cyclitis (*iridocyclitis*). While *unmixed cases of cyclitis* occur, they are *uncommon;* usually when the ciliary body is inflamed, the adjacent portions of the uveal tract (iris and chorioid) participate, and the disease is, from the start or soon afterward, *an inflammation of iris, ciliary body, and chorioid.*

Practically, the term *iridocyclitis* is reserved for those cases in which there are pronounced *symptoms of iritis,* and *in addition* the following evidences of *participation of the ciliary body:* Tenderness in the ciliary region, swelling of the upper lid, deposits upon Descemet's membrane, abnormal tension, and a greater interference with vision than can be explained by changes in the anterior chamber (due to opacities of the vitreous).

Symptoms.—The symptoms of cyclitis are those of iritis, plus the additional ones just mentioned. Cyclitis or iridocyclitis is always a *serious affection;* the inflammation is

pronounced, and the changes in the eye may be *disastrous;* it often causes *destruction of the eyeball.*

Varieties.—Cyclitis may be divided into (1) *simple,* (2) *plastic,* and (3) *purulent.*

Simple Cyclitis is often known as *Serous Cyclitis,* Serous Iritis, Keratitis Punctata, and Descemetitis; all these synonyms are objectionable. This form occurs in *young adults,* is *chronic* in its course, and is likely to *relapse;* it is apt to involve the *second eye* at a variable period after its occurrence in the first.

The symptoms vary a great deal in intensity. They include those of iritis with the special signs mentioned above. The *exudation* consists of serum and of small cells; the latter are apt to adhere to the posterior surface of the cornea (Fig. 87); hence the name *keratitis punctata.* The *anterior chamber* is *deep,* the *aqueous* often *turbid;* there may also be *increased tension* or *alternations* of increase and diminution of tension; there is often *dilatation of the pupil;* minute *opacities* form in the *vitreous* and thus *vision* is markedly *diminished;* pain is not apt to be severe.

The complications are iritis, chorioiditis, scleritis, and glaucoma.

The causes are rheumatism and gout, general debility, anæmia, and tuberculosis.

The *prognosis* is generally *good;* but there is always danger of glaucoma supervening.

Treatment is that of *iritis.* In some cases, however, *atropine* is not well borne and increases the pain. Under such circumstances there may be increased tension, and then *eserine or pilocarpine* can often be substituted with advantage.

Plastic Cyclitis.—This form is accompanied by very *pronounced symptoms of iridocyclitis;* it may be acute or subacute. The *pain* is severe; there is great *ciliary tenderness;* the *circumcorneal congestion* is marked, the color being often purplish as in episcleritis; the *anterior chamber*

is *deep;* the *pupil* is often *dilated* owing to the retraction of the periphery of the iris by the plastic exudation; *tension* is *reduced,* or there may be *alternations* of + and − tension.

The disease is rarely limited to the ciliary body; it spreads through the entire uveal tract and then constitutes *plastic uveitis.* The *exudation* is formed in the anterior chamber, pupil, behind the iris, and in the vitreous; it contracts subsequently and causes *detachment of the retina* with complete *blindness.*

The degenerated eyeball shrinks, and the condition is then known as atrophy of the eyeball. The affection may now become quiescent; but from time to time there are apt to be *attacks of pain,* and the shrunken eyeball is often a *constant menace to the other eye.* This form of inflammation has a great tendency to cause sympathetic uveitis in the other eye (*sympathetic ophthalmia*). Though the disease is capable of being cured in the early stages and leaving the eye in a more or less useful condition, the *majority of such eyes are lost.*

The *cause* is usually an *injury of the ciliary region,* either as a result of violence or after operations upon the eyeball, especially cataract extraction. The *treatment* is that recommended for *iritis.*

Purulent Cyclitis is an inflammation of the ciliary body with the *formation of pus.* Strictly speaking, it is always an iridocyclitis and as such can be divided into two varieties.

In the *non-septic form,* the term "purulent" merely refers to the presence of pus in the anterior chamber; the course of the disease resembles that of acute iritis, and its *prognosis* is equally *favorable.*

In the second class of cases, the one usually meant when purulent iridocyclitis is spoken of, there is a *septic inflammation of the ciliary body, iris,* and usually *chorioid,* with the formation of pus. Such an inflammation may be set up

by *septic emboli* after pyæmia and puerperal septicæmia, and also occurs after meningitis and cerebro-spinal meningitis in children (*metastatic*). But the usual cause of purulent iridocyclitis is an *injury to the ciliary region*, including operative wounds; also *infected ulcers of the cornea.*

The *symptoms* are always *pronounced.* Besides those present in a severe case of iridocyclitis, there is apt to be marked congestion of the conjunctiva with chemosis, and swelling of the lids. Pus forms in the anterior chamber and in the vitreous; if the usually clouded cornea and aqueous permit, a *yellow reflex* is obtained from the vitreous.

Though the disease may yield to treatment when seen early, the *prognosis* is always *grave.* The cases following pyæmia, septicæmia, and meningitis soon involve the entire uveal tract in the purulent process and terminate in *blindness*, shrinking of the eyeball causing *atrophy* of the globe. In other cases the disease extends to all the structures of the eyeball and terminates in *panophthalmitis* (p. 167). The *treatment* is that of iritis.

INJURIES OF THE CILIARY BODY.

The *ciliary region*, represented by a ring about 6 mm. wide around the cornea, is known as the "*dangerous zone*," because penetrating wounds in this situation are apt to set up *plastic cyclitis*, which may be followed by *sympathetic ophthalmia.* In wounds of this region, if there be no prolapse of the ciliary body and no foreign body in the eye, a *bandage* may be applied after thorough *cleansing*, and a suture used if the wound be large and gaping. Prolapses of the iris and ciliary body are usually abscised. Additional details of treatment are given in the paragraph on Sympathetic Ophthalmia (p. 163).

CHAPTER XII.

DISEASES OF THE CHORIOID.

Anatomy and Physiology.—The chorioid is a *dark brown membrane* placed between the sclera and the retina. Anteriorly it is continued into the iris, but before passing into the latter, it presents a number of thickenings, the *ciliary processes*, which, with an underlying zone of unstriped muscular tissue, the *ciliary muscle*, constitute the *ciliary body*.

The chorioid itself extends from the ora serrata to the aperture for the optic nerve. It consists mainly of *blood-vessels*, united by delicate connective tissue containing numerous *pigmented cells;* these vessels are arranged according to their calibre into three superimposed layers.

This vascular structure is bounded on either side by a non-vascular membrane; accordingly, the chorioid can be divided into *five layers:* (1) Externally, the *suprachorioid*, a non-vascular membrane connected with the sclera by loose connective tissue, vessels, and nerves. (2) The layer of *large vessels;* the spaces between these are filled with connective tissue and cells. The arteries are the short ciliary. The veins are arranged in curves (*vasa vorticosa*) converging to four or five principal trunks which pierce the sclera near the equator of the eyeball. (3) The layer of *medium-sized vessels*. (4) The layer of *capillaries* (chorio-capillaris). (5) The *lamina vitrea*, a structureless, transparent membrane which is placed next to the pigmentary layer of the retina.

The *function* of the chorioid is chiefly to serve as a *nutri-*

ent organ for the retina, vitreous, and lens. It forms the *dark coating* of the interior of the eyeball.

Inflammations of the chorioid, chorioiditis, may be (1) *exudative or non-purulent*, and (2) *purulent*.

EXUDATIVE, NON-PURULENT, OR PLASTIC CHORIOIDITIS.

This variety of chorioidal inflammation occurs under the following principal forms: (1) *Disseminated*, (2) *central*, including the *myopic* and *senile* varieties, and (3) *syphilitic*. In many instances, the disease involves the retina as well as the chorioid, and is then properly spoken of as *chorioido-retinitis* or *retino-chorioiditis*. It will be of advantage to describe *Exudative Choroiditis in General*, before giving the distinctive features of the several varieties.

Subjective Symptoms.—There are *disturbances of vision*, both *diminution in acuteness* and *distortion* of objects (*metamorphopsia*); the latter symptom may be divided into *micropsia*, when objects appear too small, and *macropsia*, when they appear too large. There are often *flashes of light*, sparks or bright circles before the eyes. In the later stages there may be *defects in the field of vision*, both scotomata and peripheral contraction. There is no pain.

Objective Symptoms.—There are no external signs, but the *ophthalmoscope* reveals a well-marked picture. There are *patches of exudation* of plastic material, varying in size and position. At first these areas are *yellowish or yellowish-white* in color, with *ill-defined margins*; the retinal blood-vessels are seen to be lifted and to pass over them. Later, after several weeks or months, the exudation becomes absorbed, leaving *patches of chorioidal atrophy*. The latter appear as *whitish areas* (the sclera showing through) often marked with distinctly visible chorioidal vessels. The atrophic spots are of various shapes and more or less *pigmented*. Not infrequently the *vitreous* is involved, and

then there are *opacities* of this medium. Very often the *retina* becomes *atrophied* opposite the patches just described. The *optic disc* may participate in the changes and present a yellowish-white, dirty color—a condition often spoken of as "*chorioidal atrophy.*" The *sclera* may become involved and yield, causing a bulging or *staphyloma.*

Complications.—From this description it will be seen that neighboring structures are frequently implicated: *Iris, retina, vitreous,* and *sclera;* chorioiditis may also cause posterior polar cataract.

Etiology.—Many cases are due to acquired or hereditary *syphilis.* Many examples are found in *myopia.* Some cases are apparently dependent on tuberculosis and anæmia; in others no cause can be found.

Prognosis *depends upon the position of the patches* of exudation with subsequent atrophy. A single patch involving the macular region will seriously impair vision. On the other hand, the process may extend over a considerable part of the fundus and yet vision remain good, if the macula escapes.

Treatment.—*Rest* of the eyes; in acute cases, general bodily rest. Avoidance of bright light and use of *smoked glasses. Iodide of potassium and mercury* are used, especially in specific cases, but also in others. General tonics. Diaphoretics. In recent cases, local bloodletting behind the mastoid process.

Disseminated Chorioiditis (Fig. 90, Plate III.) presents numerous round or irregular *spots scattered* over the fundus. The entire fundus may be studded, and yet the vision remain good if the macular region escapes. This form of chorioiditis runs a very *chronic course.* After existing a long time, atrophy of the retina and optic nerve may be added.

Central Chorioiditis is a form in which the changes are *limited to the macula,* and which occurs most frequently in *myopia of high degree.* It results in *serious interference*

with vision and causes *central scotoma*. It also occurs as a result of senile changes (*senile central chorioiditis*) and in *syphilis*.

Syphilitic Chorio-Retinitis is the name given to a *diffuse* inflammation of the chorioid, associated with *retinitis* and *changes in the vitreous*, which occurs in the secondary stage of syphilis. At first there are *diffuse cloudiness* of the retina, numerous *exudations* in the chorioid, especially in the region of the macula, and fine, *dust-like opacities of the vitreous*. Later, the cloudiness of the retina is replaced by *atrophy*, there are atrophic patches of the chorioid, spots of *pigment*, and *opacities of the vitreous*.

Chorioiditis of Myopia, Posterior Staphyloma, or Sclero-Chorioiditis Posterior.—The fundus of nearsighted eyes, especially if the myopia be of high degree, very often presents *characteristic changes* (Fig. 91, Plate III.). Owing to the elongation of the eyeball, there is a *bulging of the sclerotic* at the posterior pole and *atrophy of the chorioid* in this situation. This shows itself in a white crescent (*myopic crescent*) situated usually to the outer side of the disc, varying in size, and sometimes encircling the papilla. It is known as posterior staphyloma or sclero-chorioiditis posterior.

When this crescentic or annular patch is separated from healthy chorioid by a sharply defined margin, often pigmented, it is a sign that the process has come to a standstill. But when the border is ill-defined, it indicates that the changes are advancing (*progressive myopia*); such knowledge is of great importance in emphasizing the necessity for attention to ocular and general hygiene. The size of the staphyloma is usually, but not always, proportionate to the degree of myopia. More or less *superficial atrophy* of the chorioid is often observed in *myopia* of high degree, allowing the larger *chorioidal vessels* to become *plainly visible*. Besides chorioiditis in the *macular region*, there may be patches of chorioidal atrophy in *other parts* of the fun-

FIG. 90.—Disseminated Chorioiditis.

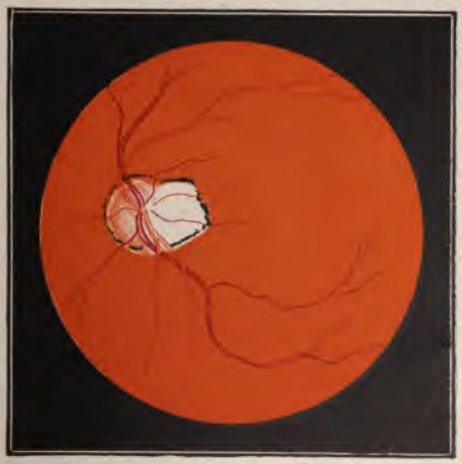


FIG. 91.—Posterior Staphyloma.

dus; these often coalesce with the posterior staphyloma, so that an extensive white area is seen, spotted or bordered with more or less pigment. The early changes in the macular region may be represented by fine lines or fissures. *Hemorrhages*, especially in the macular region, and *opacities of the vitreous* also occur in myopia of high degree.

The *treatment* consists in *avoidance of near work*, *rest* for the eyes, *smoked glasses*, *out-door life*, and attention to the *general health*. During the progressive stage, the treatment recommended for chorioiditis in general is indicated.

PURULENT CHORIOIDITIS.

In this affection, the *chorioid*, *ciliary body*, and *iris* are involved in a *purulent inflammation* which leads to the *destruction of the eyeball*. In most cases all the structures of the eyeball are included and *panophthalmitis* results (p. 167).

The symptoms, those of *iritis and cyclitis* already given, are apt to be *acute and severe*. The *pain* may be slight or marked; the *congestion* of the conjunctiva is pronounced, with *chemosis* and *swelling* of the lids. The *cornea becomes clouded*, and *pus appears* in the aqueous and vitreous so that no details of the fundus are visible. *Sight is rapidly lost*.

In those cases in which the process remains limited and panophthalmitis does not result, after the acute symptoms subside, a sightless, *degenerated, and atrophied eyeball* remains. A yellowish or grayish-yellow reflex is then obtained from the interior of the eye, due to the purulent degenerated mass. This is known as *pseudo-glioma* on account of its resemblance in color to glioma of the retina.

Etiology.—It may be due to *metastasis* in pyæmia and puerperal septicæmia; it occurs from *extension* in thrombosis of the orbital veins; it is also found as a complication of *meningitis* and cerebro-spinal meningitis, especially in

children. Most cases are due to *infected wounds* of the eyeball from external violence, operations, or *after infective ulcers.*

Treatment resembles the management of iritis. If the process has involved all the ocular structures, the treatment of panophthalmitis is indicated.

Coloboma of the Chorioid is a *congenital defect* of the chorioid and retina, showing itself in a *large white patch,* representing the exposed sclera; it is usually situated below the disc. The retinal vessels are seen passing across this patch. There is a *scotoma* corresponding to the defect. This condition is often associated with *coloboma* (a cleft) *in the iris.*

Rupture of the Chorioid sometimes results from *contusions* of the eyeball. The immediate effect of such an injury is an extravasation of blood into the vitreous. After this is absorbed a long, *yellowish-white streak* with pigmented edges is seen, usually in the neighborhood of the disc and to its outer side.

Sarcoma of the Chorioid (see Intraocular Tumors).

CHAPTER XIII.

DISEASES OF THE WHOLE UVEAL TRACT. UVEITIS.

As its name implies, *uveitis is an inflammation of the whole uveal tract:* iris, ciliary body, and chorioid. There are *two forms:* (1) *serous and plastic*, and (2) *purulent.* Both forms have been described in connection with cyclitis, which, as already explained, is generally merely part of a uveitis. There are, however, *two special varieties:* (1) *Sympathetic Uveitis*, generally known as *Sympathetic Ophthalmia*, and (2) the form of *purulent uveitis* known as *Panophthalmitis.*

SYMPATHETIC OPHTHALMIA.

Sympathetic Ophthalmia (sympathetic ophthalmitis) is a *serous or plastic inflammation of the uveal tract* in one eye due to the effects of a similar inflammation in the other.

Etiology and Occurrence.—This inflammation is usually due to a *perforation of traumatic, infective origin*, or to *operations, in the ciliary region*, especially if the iris or ciliary processes be entangled in the wound. *Foreign bodies* in the interior of the eyeball are also apt to excite this disease. Sometimes it results from the iridocyclitis following *perforating corneal ulcers.* Rarely it occurs without any perforating lesion.

It is, fortunately, *not of very frequent occurrence*, for it is a *most serious* disease, on account of its tendency to cause *blindness.* It occurs most frequently in the young, especially in *children*, but may be met with at any age. It was

formerly more common than it is at the present time when asepsis and antisepsis have lessened the danger of its occurrence after operations. It usually begins between *five and eight weeks after the injury* in the exciting eye, rarely before three weeks; it may, however, occur many months or even years after the injury.

The eye which has been *originally affected* is known as the *exciting eye;* the one *secondarily involved,* as the *sympathizing eye.*

Symptoms.—In most cases, but not invariably, the disease presents a stage known as *sympathetic irritation;* it is very important to recognize this stage, since removal of the exciting eye at this period will prevent the progression of the affection from irritation to actual inflammation.

The Symptoms of Sympathetic Irritation.—The *sympathizing eye* is "*irritable*"; there are marked *photophobia* and *lachrymation; neuralgic pain* in the eye and neighboring parts; *dimness of vision* occurs when the eyes are used for near work; there may be *bright and colored sensations.*

The exciting eye usually presents an *iridocyclitis or uveitis,* which may be slight or severe; when the sympathizing eye becomes affected, there may be symptoms of irritation and marked tenderness over the ciliary region in the exciting eye.

These symptoms of irritation in the sympathizing eye may be *intermittent;* each attack may last a number of days or weeks, then subside, and recur a number of times. They may finally disappear entirely. But, as a rule, if the exciting eye is not excised *sympathetic inflammation results.*

The Symptoms of Sympathetic Inflammation.—These may follow directly upon those of irritation, or may occur after the sympathizing eye has been quiet for a time. They may *begin acutely or insidiously.* When once established the inflammation is *chronic,* and its duration is months or even one or two years. In the majority of cases *blindness*

results, though occasionally, if the inflammation be mild, useful vision may be preserved.

The symptoms are *photophobia*, *lachrymation*, *dimness of vision*, and *tenderness in the ciliary region*. There will be *circumcorneal injection*, *punctate deposits* upon Descemet's membrane, *increased depth* of the anterior chamber, *contracted pupil*, and *increased tension*.

In mild cases the symptoms may not pass beyond those of cyclitis or iridocyclitis; but usually they develop into a *plastic uveitis* including iris, ciliary body, and chorioid, and giving the following signs: The *iris is thickened*, its *color* becomes *changed*, its *markings are obliterated*, and it presents *new blood-vessels* upon its surface; it is firmly bound down by numerous and extensive *posterior synechiæ*. The *plastic exudation* fills up the pupil and more or less of the anterior chamber, which becomes shallow. *Tension is diminished*. The *chorioid and retina* participate in the plastic inflammation, the *vitreous* presents numerous *opacities*, and the *lens* becomes opaque. Finally, there is *detachment of the retina*, the eyeball *shrinks* and passes into the condition of *atrophy*.

Theories of Transmission.—The mode of transmission is *not definitely known*. The theories which have been propounded are: (1) Conveyance by *blood-vessels*, (2) irritation through ciliary and optic *nerves*, and (3) *infection* spreading through the *sheath of the optic nerve* of one side to the chiasm and sheath of the optic nerve of the other eye; the last is considered the most probable explanation.

Treatment.—*Prophylactic treatment* is of the greatest importance, and refers to the *removal of the exciting eye* under the following circumstances: We should *enucleate the injured eye* if it be *sightless*, or its condition such (especially when the *ciliary region* is involved) that we cannot hope to preserve useful vision; this is particularly imperative if it is *irritable*, has *ciliary tenderness*, presents the signs of

iridocyclitis, or contains a *foreign body* which cannot be extracted.

When, however, there is *useful vision in the injured eye*, or a good chance of obtaining fair sight in this eye, the question of enucleation is often a difficult one to decide, since symptoms of sympathetic irritation may appear and then subside, and yet sympathetic inflammation never develop. In such cases we are often justified in waiting, if the injured eye remain *quiet and free from inflammation*, providing we can keep such a patient *under constant observation*.

After sympathetic inflammation has made its appearance, enucleation of the injured eye has no effect upon the progress of the disease; and the exciting eye may ultimately possess better vision than its sympathizing fellow. Hence, under such circumstances, the exciting eye should not be removed if it possesses vision; if blind and exhibiting signs of inflammation, it should be enucleated, since its presence may aggravate the condition in the sympathizing eye.

The treatment of the sympathetic ophthalmia itself consists in the use of *atropine* (unless this seems to aggravate the symptoms), *hot compresses*, *absolute rest*, *shaded* room, and smoked coquilles; *leeches* to the temple are sometimes of advantage. *Mercurialization* is frequently resorted to, either calomel internally or inunction of the oleate up to the point of salivation. Since the disease is of lengthy duration, the *general health* of the patient must be looked after.

Though the *prognosis is unfavorable* and most cases end in blindness, the treatment must be carried out rigidly and patiently; in some cases at least, especially if the inflammation be of the *serous type*, *fair vision* may ultimately be obtained.

PANOPHTHALMITIS.

An intense *purulent inflammation of the entire uveal tract*, which fills the eyeball with *pus*, and ends in *complete destruction* of this organ. It is due to *infection*. It resembles *purulent chorioiditis* (which term is often employed as a synonym), but the inflammatory process is more extensive.

Etiology.—It is almost always due to *infected wounds* of the eyeball, whether accidental or as a result of operations. It may also result from *infective ulcers*, *metastasis* in pyæmia and puerperal septicæmia, *meningitis*, and cerebrospinal meningitis, especially in children.

Symptoms (already described in connection with purulent chorioiditis, p. 161) are apt to be *acute and severe*. The disease is usually ushered in by a rise of temperature, *general febrile symptoms*, headache, and sometimes vomiting. There are severe *pain* in the eyeball, rapid *loss of sight*, intense ciliary and conjunctival *congestion*, marked *chemosis*, and *swelling and redness of the lids*. The *iris* soon becomes involved, the *anterior chamber* and *vitreous* become filled with *pus*, the *cornea is clouded* and yellow, and *tension increased*. There is infiltration of Tenon's capsule, followed by *exophthalmos* and limitation of the movements of the eyeball.

Pus usually *breaks* through the anterior portion of the sclera, after which the pain and other symptoms *subside;* in the course of several weeks the process has run its course, leaving a *shrunken, sightless eyeball* (phthisis bulbi).

The Prognosis is always unfavorable: sight is invariably lost. The condition does not cause sympathetic ophthalmia.

Treatment.—The indications are to *alleviate pain* by the use of *hot, moist compresses*, and to *incise the sclera* so as to allow the escape of pus. It is not considered advisable to enucleate in the inflammatory stage, on account of the danger of setting up purulent meningitis (p. 74).

CHAPTER XIV.

INTRAOCULAR TUMORS.

Intraocular tumors are *rare*. Their recognitior is, however, important, since early enucleation of the eyeball may save life. There are two varieties: (1) Sarcoma of the Chorioid, and (2) Glioma of the Retina.

SARCOMA OF THE CHORIOID.

This *malignant* growth usually occurs in *adults* between the ages of forty and sixty. It is always *primary*, *single*, and involves *one eye* only. It may be formed of *spindle* or of *round cells*, and is usually *pigmented* (*melano-sarcoma*). It forms a *rounded mass* which springs from the chorioid, most commonly near the posterior pole, and advances toward the centre of the eyeball, pushing the retina before it.

Symptoms.—There are *four stages*.

In the *first or quiescent stage*, there will be a *defect in the field* and *diminution in sight* depending upon the exact seat of the tumor. With the ophthalmoscope a *yellowish, brown, or black mass* may be seen, over which retinal vessels can be traced, and behind these other *vessels* belonging to the tumor itself. But very frequently the *retina becomes detached* and thus obscures this picture. The anterior ciliary veins may be found dilated near the seat of the growth. This stage usually lasts from eighteen months to two years.

In the *second or irritative stage*, the *tumor enlarges* in size and gives rise to *pain* and other symptoms of inflammatory *glaucoma*.

In the third or extraocular stage, the tumor *bursts through the globe* and then *increases very rapidly* in size, and *ulcerates*. In most cases it perforates anteriorly, and a dark mass is seen. If it perforates posteriorly, exophthalmos results. It soon *implicates neighboring structures*, including the brain.

The *fourth stage* is distinguished by the occurrence of *metastases*, most frequently in the *liver*.

Differential Diagnosis.—Sarcoma of the chorioid may be mistaken for *detachment of the retina*, *glaucoma*, or possibly *glioma* of the retina; the last, however, occurs only during the first years of life. Ordinary detachment of the retina usually occurs suddenly in a myopic eye, or after a blow, and tension is diminished. From primary glaucoma sarcoma of the chorioid is distinguished by the fact that sight is involved before the inflammatory symptoms appear, there are no premonitory symptoms such as usually precede glaucoma, nor remissions in symptoms, one eye only is involved, and the characteristic field of glaucoma (nasal limitation) is not present.

Treatment.—*Enucleation as soon as the diagnosis is established*, cutting the optic nerve far back. It may be necessary to clear out the entire contents of the orbit. There is always danger of *local recurrence* and of *metastases* in internal organs. The affection is invariably fatal when not removed early, death taking place within five years.

GLIOMA OF THE RETINA.

A *malignant growth*, consisting of *small cells* with some soft basement substance and blood-vessels; it occurs in *children* under five, usually in *one eye*, at times in both, and occasionally in successive children of the same family.

Symptoms.—We distinguish *three stages*.

In the *first or quiescent stage* there are no inflammatory symptoms. The ophthalmoscope shows small *whitish or*

yellowish masses with *metallic lustre*, growing into the vitreous; the surface presents *newly formed blood-vessels* and may also show hemorrhages and white patches. The attention of the parents is attracted by the *striking yellow reflex*, easily seen through the pupil, which is usually in a condition of *dilatation*; this symptom has given rise to the synonym "*amaurotic cat's eye.*"

In the *second or irritative stage* there are *pain, increase of tension*, and other symptoms of *glaucoma*. The tumor *increases in size* and extends into the vitreous. Very soon the growth can no longer be seen on account of *turbidity of the media*.

In the *third or extraocular stage* there is bulging of the eyeball, both *staphyloma and exophthalmos*, and then *perforation* takes place. The growth passes backward along the optic nerve to the *brain* (in this way it becomes fatal), and forward though the cornea and sclera, *increasing in size* rapidly and involving all tissues with which it comes in contact. Metastases are rather rare.

Differential Diagnosis.—We must distinguish glioma from pseudo-glioma (p. 161), the degenerated eyeball which is the outcome of purulent chorioiditis following meningitis or cerebro-spinal meningitis in children. In the latter affection there will be the history of a previous acute febrile disease with inflammation of the eyeball, and tension is diminished; with the ophthalmoscope we fail to see the irregular curved surface covered by newly formed vessels, and there are signs of previous inflammation of the iris. When in doubt, such eyes being always sightless, we should *enucleate*.

Treatment.—*Enucleation as soon as possible*, cutting the optic nerve far back. If the growth has perforated, the entire orbit must be cleaned out; even then there is danger of *recurrence*. When excision is practised early there is a fair chance of cure. Unless this is done death occurs within two or three years.

CHAPTER XV.

GLAUCOMA.

Anatomy.—The *aqueous chamber* is bounded in front by the cornea, behind by the lens and its suspensory ligament, and on each side by the ligamentum pectinatum and anterior portion of the ciliary body (Fig. 92). Its depth varies; it is comparatively deep in the young, in myopic eyes, and when the eye is focussed for distant objects. The iris divides the aqueous cavity into an *anterior* and a *posterior chamber*. The former lies in front of the iris. The latter is the triangular space between the iris and the lens; since the iris is in contact with the lens only at its pupillary margin, this space increases in depth from the pupil to the peripheral border of the iris, and is triangular in cross-section. The posterior communicates with the anterior chamber by means of the pupil.

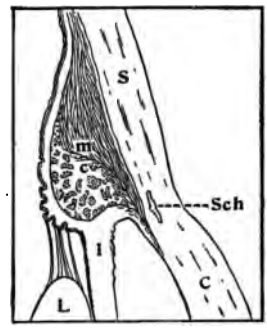


FIG. 92.—Section of the Eyeball at the Sclero-corneal Junction, Showing Angle of Anterior Chamber. *S*, Sclera; *C*, cornea; *I*, iris; *L*, lens; *cm*, ciliary muscle; *Sch*, canal of Schlemm.

The portion of the anterior chamber where the sclero-corneal margin, iris, and ligamentum pectinatum meet is known as the *angle* or *sinus of the anterior chamber* (often called the *iris angle*). This region is of *great importance;* upon its integrity depends the proper circulation of the lymph which nourishes the anterior portion of the eyeball.

The ligamentum pectinatum is formed by the breaking up of Descemet's membrane at the margin of the cornea, into bundles which connect the sclera with the root of the iris. These elastic laminæ are covered by endothelium continued from Descemet's membrane. In this way spaces are formed which are continuous with the cavity of the aqueous, are lined with endothelium, and are known as the *spaces of Fontana*. To their outer side, at the sclero-corneal junction, is *Schlemm's canal*, a plexus of veins.

With the exception of the conjunctiva, no portion of the eyeball contains lymphatic vessels; in place of such vessels and serving the same function, there are *lymph channels and lymph spaces*. These may be divided into those of the anterior and those of the posterior portion of the eyeball.

The anterior lymph spaces and cavities consist of the aqueous chamber and the parts immediately around the iris angle. The anterior and posterior chambers represent two large lymph spaces which collect the lymph of the anterior portion of the eye. This lymph is known as the *aqueous humor*, and consists of a clear, watery fluid, secreted by the epithelium covering the ciliary processes and the posterior surface of the iris. It first passes into the posterior chamber, then through the pupil into the anterior chamber, and leaves the eye through the spaces of the ligamentum pectinatum (Fontana's spaces) and Schlemm's canal, passing into the anterior ciliary veins; a portion passes into the lymph spaces of the iris, and thence to the suprachorioidal lymph space.

The *posterior lymph passages* consist of the hyaloid canal of the vitreous, and of the suprachorioidal space (between chorioid and sclera), communicating with Tenon's space along the venæ vorticosæ; both have for an outlet the supravaginal and infravaginal spaces of the optic nerve.

GLAUCOMA.

Glaucoma is an *important and common* disease of the eye, which has for its characteristic sign an *increase of intraocular tension.*

Varieties.—It is (1) *primary,* when occurring without antecedent ocular disease, and (2) *secondary,* when it follows as a result of some pre-existing disease of the eye.

Primary glaucoma occurs under two forms: 1, *Inflammatory or Congestive,* and 2, *Non-inflammatory or Non-congestive,* usually spoken of as *Simple*

The *inflammatory* variety is again divided into 1, *acute, and* 2, *chronic.*

These variations in clinical types of primary glaucoma are explained by the *rapidity* with which the increase of intraocular pressure shows itself and the *height* to which it rises. When the increase of tension is rapid, the *inflammatory* type results; when gradual, the eyeball accommodates itself to a certain extent to the altered conditions, and symptoms of inflammation or congestion are absent or only very slightly marked; the disease is then known as *simple glaucoma (non-inflammatory or non-congestive glaucoma);* this type is *always chronic* in its course.

All forms of glaucoma present very characteristic *remissions or intermissions* in the course of the disease.

ACUTE INFLAMMATORY GLAUCOMA.

Symptoms.—Glaucoma presents a clinical picture which *varies with the type of disease,* depending upon the suddenness of onset, duration, and the presence or absence of congestive signs—hence the classification into *acute* and *chronic* inflammatory cases; intermediate cases are sometimes described as *subacute.*

The affection can be divided into *three stages:* 1, the

prodromal stage, 2, the stage of *active glaucoma*, and 3, the stage of *absolute glaucoma*. To these we may add a fourth stage, the stage of *degeneration*.

The Prodromal Stage.—This stage is present in most instances; it may, however, be absent. There will be some *diminution in the acuteness of vision*—the sight appears to be obscured by *fog*. A *ring of rainbow tints* will be seen around lights; the *cornea*, especially at its centre, will, upon careful inspection, be found slightly *clouded;* this condition (œdema) is the cause of the preceding symptoms. There will be a feeling of *dulness or slight pain* in the eye and head. The *anterior chamber* is rather *shallow*, the *pupil* somewhat *dilated*, often *oval*, and *sluggish* in reaction. The *tension of the globe is increased*. There is often slight *circumcorneal injection*.

These symptoms last for a number of hours and then disappear entirely; the eye then returns to a normal condition, except that there is a *diminution in the power of accommodation*, so that the patient requires *stronger glasses* than are natural at his age. Hence a *rapid increase of presbyopia* should always excite suspicion of glaucoma. Such prodromal attacks are often *excited by insomnia*, *worry*, dissipation, insufficient food, some condition which causes venous congestion, and sometimes by a hearty meal, indigestion, or the local use of *atropine*. They are apt to be relieved by sleep. At first the attacks are separated by *intervals* of weeks or months, but they soon become more frequent.

This stage lasts a number of weeks or months, sometimes several years; then the disease suddenly passes into the second stage.

The Stage of Active Glaucoma.—The *sudden onset* which characterizes this stage may be due to one of the exciting causes which bring on the prodromal attacks. There are *rapid failure* of *sight*, *contraction of the visual field* especially on the *nasal side* (Fig. 93), and severe *pain in the eye*,

radiating along the branches of the fifth nerve and causing violent *headache;* this pain is sometimes so severe that it occasions nausea, vomiting, general depression, and febrile disturbances, such attacks having been mistaken for "bilious attacks."

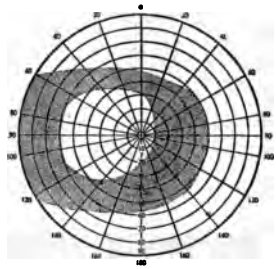


FIG. 93.—The Field of Vision in Glaucoma. Peripheral contraction especially on the nasal side.

Objective examination reveals marked *increase in tension;* the *cornea* is clouded or *steamy* (due to œdema), often presents punctate opacities, and is *insensitive* (from pressure upon nerve filaments); there is pronounced *circumcorneal injection* of a dark red color; the *episcleral veins are prominent.* The *pupil is dilated, oval, immobile,* and often presents a *greenish* reflex. The *iris* is congested, *discolored,* and *dull.* The *anterior chamber is shallow,* the aqueous sometimes turbid. The lens and the periphery of the iris are pushed forward. The *lids* are *swollen* and *œdematous.* The ocular *conjunctiva* is markedly *congested* and *chemotic.* No details of the fundus can be seen with the ophthalmoscope, on account of the *clouding of the media.*

After a number of days or weeks a *decided improvement takes place.* The pain subsides, congestion and œdema of lids and conjunctiva disappear, the cornea clears up, and sight improves. But the eye does not return to a perfectly normal condition; it is left in a condition known as the *Glaucomatous State: Vision* is *not so acute* as it was before the attack, and the visual *field* is somewhat *contracted* especially on the *nasal side.* The *pupil* remains *dilated, oval,* and *sluggish,* the *iris discolored,* the *anterior chamber shallow, tension increased,* and there is more or less *circumcorneal injection;* the power of *accommodation is diminished.*

After a period of quiescence of variable length, *another attack* occurs similar to the first, and this is succeeded by others; each attack causes greater reduction in sight.

After a while, the increased tension causes *excavation of the optic-nerve disc* (Fig. 96) recognizable with the ophthalmoscope in the intervals between attacks, when the media are clear. The lamina cribrosa, the portion of the sclera which is perforated by the optic-nerve fibres, is most yielding and hence bulges backward with the fibres of the nerve as a result of increased intraocular pressure. With the

FIG. 94. FIG. 95. FIG. 96.

FIGS. 94, 95, 96.—Ophthalmoscopic Appearances and Longitudinal Section of the Optic-Nerve Disc. Fig. 94, Normal disc; Fig. 95, disc in optic-nerve atrophy; Fig. 96, glaucomatous excavation.

ophthalmoscope a deep depression with very steep or *overhanging margins* is seen; this is known as the *glaucomatous cup or excavation* (Fig. 97, Plate IV.). The *blood-vessels bend* sharply over the margins of this excavation and often *appear interrupted* in this situation, being again seen, more or less faintly, at the bottom of the depression. They are pushed over toward the nasal side. The veins are distended and the arteries contracted. There is *pulsation* in the veins and in the *arteries* at the disc. Pulsation in the veins is often seen in health, but *arterial pulsation* is always pathological, and is an important symptom of glau-

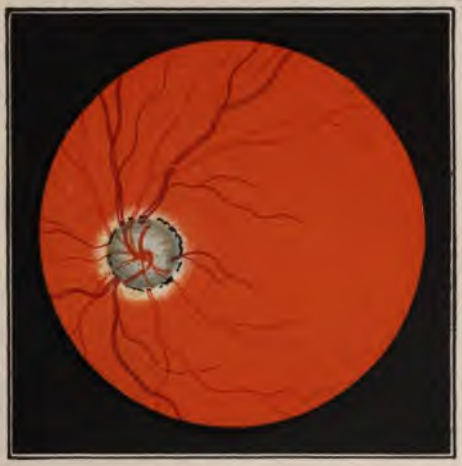


FIG. 97.—Glaucoma.

FIG. 98.—Detachment of the Retina.

coma (it is also seen in certain forms of heart disease); if not spontaneous, it can be produced by slight pressure upon the eyeball. The *optic nerve* becomes *atrophied* and the disc appears *pale*, or in late stages *greenish* or bluish. The disc is often surrounded by a whitish-yellow ring (*glaucomatous* halo or *ring*), due to atrophy of the chorioid in this situation.

The Stage of Absolute Glaucoma.—With each succeeding attack the diminution in vision becomes greater, until finally *blindness* ensues; the condition is then known as *absolute glaucoma*. There are now no inflammatory or congestive symptoms, except a dark-red zone of *circumcorneal injection* and *dilated episcleral veins*. The cornea remains clear or slightly clouded, and often more or less insensitive. The *pupil* is widely *dilated*, *immobile*, and often presents a *greenish reflex*. The *iris* is *atrophied*, narrow, gray, with a border of dark pigment. The *anterior chamber is shallow*. *Tension* is markedly *increased*. The *fundus* presents a *deep excavation* of the disc, the glaucomatous ring, and atrophy of the optic nerve. *Pain* may disappear entirely, but frequently continues, and the patient suffers from severe attacks at intervals

The Stage of Degeneration.—After absolute glaucoma has lasted a variable length of time, the eyeball is apt to degenerate. The *cornea* becomes more or less *opaque*, and frequently covered by deposits or vesicles. The *sclera bulges* and bluish-black staphylomata appear between the cornea and the equator. *Detachment of the retina* often takes place. The *lens* is apt to become *cataractous*. The patient may experience subjective sensations of light. The final result is that the *eyeball* either softens, shrinks, and *atrophies*, or else there are ulceration and perforation of the cornea, followed by iridocyclitis or panophthalmitis with subsequent atrophy of the eyeball.

Glaucoma Fulminans is the name given to a form, of rare occurence, in which very violent symptoms of inflam-

mation develop suddenly, and in which blindness may ensue in a number of hours, unless proper treatment be instituted.

CHRONIC INFLAMMATORY OR CHRONIC CONGESTIVE GLAUCOMA.

This form of glaucoma is much more *common* than the acute variety just described *Its symptoms resemble those of the acute variety, but are less intense and more gradual in their onset.* Very often the prodromal stage passes uninterruptedly into the stage of active glaucoma, and there is no succession of attacks. The ocular *conjunctiva* is *congested* and dusky, the *episcleral veins* being very *prominent;* there is *circumcorneal injection* of a dark-red color; the *cornea is steamy* and more or less insensitive; the *anterior chamber* is *shallow,* and the lens and iris are pushed forward; the *pupil* is *dilated, oval,* and *rigid,* surrounded by the *discolored,* narrow, and *atrophic iris,* and presents a *greenish* reflex. There is *pain,* but this is not so intense as in the acute form. There are gradual *loss of sight* and progressive *limitation of the field,* especially on the *nasal* side. After having lasted a sufficient length of time, the ophthalmoscope reveals the same *changes in the fundus* which are found in acute cases.

The chronic form has the same termination as the acute: *absolute glaucoma* and finally *degeneration* of the eyeball. In many cases, no sharp line of differentiation can be drawn between the acute and the chronic forms of inflammatory glaucoma.

SIMPLE GLAUCOMA.

In simple glaucoma (*Chronic Non-Inflammatory Glaucoma*), there is an *absence of any marked external symptoms;* there are *no inflammatory attacks and no pain.*

The diagnosis is made by noting the *increase of tension*, and by the picture presented when the *ophthalmoscope* is used.

This form develops very *gradually*, and may have lasted some time before the patient becomes aware of the existence of any abnormal condition. The eye may appear perfectly normal externally, or there may be *slight circumcorneal injection* and *moderate dilatation* of the *episcleral veins*. The *pupil* is slightly or *moderately dilated* and is *sluggish*. The *tension is elevated*, often moderately; sometimes the increase is not constant After the disease has lasted a certain length of time, the *ophthalmoscope* shows *glaucomatous excavation* (Fig. 96; and Fig. 97, Plate IV)., atrophy of the optic nerve, and the circumpapillary ring of chorioidal atrophy, the degree of change depending upon the duration of the process

There may be periods when the patient complains of symptoms like those in the prodromal stage: *Foggy vision*, *colored halos* around artificial lights, and *diminished accommodation*. There are gradual *loss of sight*, *premature presbyopia*, and progressive *contraction* of the visual *field*, especially on the *nasal* side. Central vision is the last portion to be lost. On this account the patient may be able to read, and yet the field of vision be quite limited.

The *course* of simple glaucoma is very *insidious* and its *duration is years;* if unchecked, it terminates in *blindness*. Sometimes this form gradually changes into the chronic inflammatory type, and then goes through the stages of the latter disease.

Etiology.—The exact cause of glaucoma is *unknown*. It is a disease of *advanced life*, occurring generally between fifty and seventy, infrequently before this period. The inflammatory form attacks women more often than men, the simple type occurs equally in both sexes. It usually involves *both eyes*, the second eye generally becoming affected

months or years after the first. There are a number of *predisposing conditions:* Glaucoma occurs much more frequently in Jews than among Christians. There is not uncommonly a history of *heredity*. *Arterial sclerosis* and *cardiac* disease, chronic *constipation*, and the *gouty* and *rheumatic* diatheses are predisposing factors. A disposition toward inflammatory glaucoma exists in *hyperopic eyes* (myopic eyes are particularly exempt) as well as in small eyeballs, and in those in which the cornea is of small size. The *exciting causes* may be the following: *Emotions* especially of a depressing character, *insomnia*, *worry*, injudicious use of *atropine*, *overuse* of ametropic eyes, insufficient food, indigestion, dissipation, various fevers especially influenza, and any condition which produces *venous congestion.*

Pathology.—All the symptoms of glaucoma can be explained by the *increase in intraocular pressure* and the resulting *venous congestion.* But the cause of this increase in tension has not yet been determined; none of the *many theories* has been adequate to explain the occurrence of this disease in every case. The increased tension must depend upon a *disturbed relationship between intraocular secretion and excretion.* The older theories assumed the existence of hypersecretion produced in various ways; these views have been discarded. It is at the present time considered more probable that the disease is due to some interference with excretion (*retention*). The obstruction to the escape of the intraocular liquids is thought to be situated at the *angle of the anterior chamber* (iris angle). It is believed that this angle (Fig. 92) is *obliterated* by pressure of the peripheral portion of the iris against the sclero-corneal junction (ligamentum pectinatum) by the congested and swollen ciliary processes, with or without *adhesive inflammation* between the opposed surfaces. As already explained, this iris angle forms the principal exit for intraocular fluids, and when it is blocked up, retention takes place. An additional causative factor is supposed to be the *nar-*

rowing of the space between the margin of the lens and the ciliary body in eyes predisposed to glaucoma. This area serves for the passage of the lymph which is secreted by the chorioid and part of that produced by the ciliary body. The circumlental space is encroached upon by the increased size of the lens with advancing age, by the comparatively large size of the ciliary body and the smaller size of the eyeball in general, in *hyperopes*. This embarrassment in the communication between vitreous and aqueous chambers would cause venous congestion, subsequent swelling of the ciliary body, overdistention of the vitreous, with the result of pushing the periphery of the iris against the sclero-corneal junction, thus blocking up the iris angle. But no explanation of the production of glaucoma satisfactorily fits all types of the disease.

Prognosis is *bad* in every case, *if proper treatment is not instituted; vision becomes worse*, more or less rapidly, but *progressively*, until complete blindness results. *With correct treatment the prognosis is more favorable.*

Differential Diagnosis.—The *inflammatory form* of glaucoma has been mistaken for *iritis* and *conjunctivitis;* the use of atropine in such cases has caused great mischief. The dilated pupil, increase in tension, turbidity of cornea, as well as the subjective symptoms ought to be sufficient to differentiate. The peculiar greenish pupillary reflex has been diagnosed as cataract, and thus valuable time has been lost in awaiting the ripening of this supposed lens change. In acute cases, the violent headache and general constitutional symptoms have misled the attendant, and been responsible for the diagnosis of some general febrile disease, at a time when active ocular treatment was urgent.

Simple glaucoma is sometimes mistaken for *optic-nerve atrophy*. In the latter case, there will be absence of increased tension, the excavation of the disc is shallow and gradual (Fig. 95), the fields present more uniform concentric contraction, and there is apt to be greater diminution

in central vision. There are, however, instances in which the differential diagnosis between these two affections is not easy.

Treatment.—(1) *Operative*, (2) *medicinal*, and (3) *general*. The most efficient treatment is *iridectomy*.

Non-Operative Treatment consists chiefly in the local use of the *myotics—eserine* and *pilocarpine*. These act by drawing the iris away from the angle of the anterior chamber; hence, they are of no value after the iris has become atrophic and is incapable of contracting, a condition observed in old cases of glaucoma. They are merely *palliative* measures, often proving only of *temporary* advantage. They may be used in the *prodromal stage* to cut short the attack, or at other times, if for any reason iridectomy cannot be performed, or the patient refuses to allow an operation to be done. They are also useful in *acute inflammatory attacks* to alleviate pain, reduce tension, and diminish cloudiness of the media and thus render iridectomy easier of execution. The myotics employed are *eserine, salicylate or sulphate* ($\frac{1}{3}$ to $\frac{1}{2}$ per cent.), and *pilocarpine nitrate* (one per cent.). The former has the stronger action, but produces more conjunctival irritation and ciliary congestion when used for a long time. These solutions are instilled two or three times a day or oftener.

General Treatment comprises rest, proper and sufficient food, salicylate of sodium, anti-rheumatic remedies, relief of constipation, correction of ametropia, avoidance of excess in eating, drinking, and late hours, the induction of sleep, and the relief of any of the other conditions which have been mentioned as predisposing to glaucoma.

Operative Treatment consists of *iridectomy*, the *excision of a portion of the iris*, and *sclerotomy*, an *incision through the sclera*.

FIG. 99.—Eye Speculum.

FIG. 100.—Fixation Forceps.

FIGS. 101 and 102.—Bent and Straight Keratome.

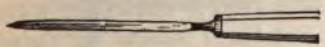


FIG. 103.—Graefe Cataract Knife.

FIG. 108.—Blunt Iris Hook.

FIG. 104.—Curved Iris Forceps.

FIG. 105.—Matthieu Iris Forceps.

FIG. 106.—Curved Iris Scissors.

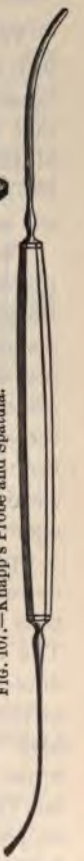


FIG. 107.—Knapp's Probe and Spatula.

FIGS. 99—108.—Instruments Required for Iridectomy.

IRIDECTOMY.

The Instruments Required include an eye speculum (Fig. 99), a fixation forceps (Fig. 100), a bent and a straight lance-shaped knife (Figs. 101 and 102) or a Graefe cataract knife (Fig. 103), a curved iris forceps (Fig. 104) or a Matthieu iris forceps (Fig. 105), curved iris scissors (Fig. 106), a metal spatula and probe (Fig. 107), and a blunt iris hook (Fig. 108).

The operation will be described as done for glaucoma. *Cocaine or holocain* may be employed in simple glaucoma. But in nervous and unruly individuals, as well as in many instances of the inflammatory forms of glaucoma, complete *general anæsthesia* is necessary, since the tense and congested tissues do not readily absorb local anæsthetics, and the cutting of the iris is painful. Lately, a watery solution of suprarenal capsule has been used in connection with cocaine or holocain, and the combined effects of these agents have produced a more satisfactory anæsthesia.

Operation.—Iridectomy for glaucoma is usually done *upward*, so that the defect is covered by the upper lid, thus limiting troublesome optical effects of the coloboma. The operator, standing behind the patient's head, introduces the speculum, obtains a firm grasp of the conjunctiva at the lower margin of the cornea, directs the patient to look down, and thrusts the lance-shaped knife into the upper part of the cornea, entering 1 mm. behind the limbus (Fig. 109); the knife is directed perpendicularly until its point is seen in the anterior chamber, and then pushed forward in a direction parallel to the plane of the iris until the corneal wound is of sufficient size (6 to 8 mm.); care is taken not to pass between the layers of the cornea, nor to wound the iris or lens capsule. The knife should be *withdrawn slowly* so that the reduction in tension is not too sudden, which might cause intraocular hemorrhage and

other injury; its point is directed toward the cornea without scraping its posterior surface. When there are considerable increase in tension and a very shallow anterior chamber, the Graefe knife is usually preferred for the corneal incision. It is made to enter 1 mm. behind the limbus, at about the junction of the lower five-sixths with the upper sixth, passes across the anterior chamber (great care being exercised not to wound the iris or lens

FIG. 109.—Section of the Cornea in Iridectomy.

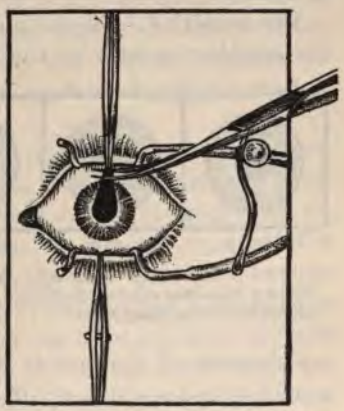


FIG. 110.—Division of the Iris in Iridectomy.

capsule), and emerges at a corresponding point 1 mm. behind the limbus on the opposite side, the incision being completed by to-and-fro movements.

An assistant now takes the fixation forceps. The operator passes the closed iris forceps through the corneal incision to the pupillary margin, opens the instrument, seizes the pupillary border of the iris between its branches, draws the iris out of the wound, and cuts it off close to the cornea, the blades of the iris scissors being parallel to the wound (Fig. 110). This can be done either with one cut, or with two or three cuts; in the latter case, the first stroke divides the iris at one corner, the second the central part (or this

part may be loosened by tearing), and the third the iris at the other corner of the wound. The piece of iris removed should be at least one-fifth of the entire circle (Fig. 111), and should comprise the entire width including the ciliary attachment.

In iridectomy occurring in an aphakial eye (after cataract operations), it is difficult to grasp the iris with forceps; in such cases the iris is drawn out with the blunt hook (Fig. 108).

The resulting *coloboma* must be large, cleanly cut, and the pupillary margin of the iris must return to its natural position producing a *keyhole-shaped pupil* (Fig. 111). No iris tissue must be left in the wound, since this causes subsequent irritation and complications. Proper replacement of the iris is accomplished by stroking the wound with a spatula, or, if this is unsuccessful, by passing the spatula into the incision and freeing the angles.

FIG. 111. FIG. 112. FIG. 113.

FIG. 111.—Iridectomy in Glaucoma. FIG. 112.—Iridectomy Preceding Cataract Extraction. FIG. 113.—Iridectomy for Artificial Pupil.

Hemorrhage into the anterior chamber is common; the blood is usually absorbed in a few days; it is not wise to make too great efforts to dislodge the blood, since undue pressure may cause the lens to become cataractous.

Both eyes are bandaged, and the patient is kept quiet in bed. After two or three days, the unoperated eye may be left uncovered. Recovery is smooth in most cases; in some cases the anterior chamber is not re-formed for a number of days. Cystoid cicatrix sometimes results—a condition which is not objectionable and is thought to facilitate filtration.

Results of Iridectomy in Glaucoma.—The manner in which iridectomy relieves glaucoma is not definitely known.

The *earlier* the operation is performed, the more sight is preserved. Hence it is advisable to do the operation *as soon as possible.* The best time is during the prodromal stage, in the interval between attacks. In inflammatory cases, during the stage of acute glaucoma, the operation is very difficult on account of the severe congestion and the shallowness of the anterior chamber; under such circumstances, it is usually advisable to instil eserine or pilocarpine at frequent intervals for a day or two, so as to reduce tension and increase the depth of the anterior chamber, and then to operate; but if these myotics do not act, the operation must be performed without further delay.

The most favorable results of iridectomy are seen in cases of *acute inflammatory glaucoma;* in such instances pain and inflammatory symptoms subside rapidly and sight returns up to the degree possessed before the onset of the attack. Furthermore, the results are generally *lasting.* Exceptionally the effects of an iridectomy are disappointing or *temporary,* and the operation has to be repeated opposite to or at the side of the first. In rare cases operation has no effect upon the course of acute inflammatory glaucoma, and the disease progresses until blindness ensues.

In chronic inflammatory glaucoma, the results of iridectomy are *favorable,* but not so brilliant as in acute cases. The operation relieves the pain and inflammatory symptoms, and the media again become clear; but since the disease has already caused permanent changes in the disc and optic nerve, the restoration of sight is limited. But the *progress of the disease is generally checked,* though sometimes a second operation must be performed. In a certain number of cases, however, there is progressive diminution in sight notwithstanding the operative intervention.

In simple glaucoma, iridectomy is also indicated, but its results are *less marked and less permanent* than in the inflammatory variety. The most that we can expect from

the operation is that the acuteness of vision prevailing at that time will be preserved or slightly increased, and that the *progress of the disease will be arrested.* This happens in about one-half the cases. In the other half the results are not so favorable. In some of these, the effects of the operation are only *temporary* and the iridectomy has to be repeated; in others, the *disease progresses* after a shorter or longer interval of arrest, and blindness finally ensues. In a very small proportion, the operation has an unfavorable effect upon the disease; violent inflammatory symptoms appear immediately after the operation and the eye rapidly becomes blind; such cases are known as *malignant glaucoma.*

In *absolute glaucoma, enucleation* is often indicated for the relief of severe pain.

Indications for Iridectomy.—Besides (1) glaucoma, the operation is indicated in (2) some cases of chronic and recurrent iritis and iridocyclitis; (3) complete circular synechia; (4) partial corneal staphyloma; (5) tumors and foreign bodies in the iris; (6) recent prolapse of the iris; (7) as a part of the operation of extraction of cataract—here the coloboma should be smaller than in glaucoma (Fig. 112); (8) as a means of improving sight (artificial pupil, optical iridectomy) in central opacities of the cornea and lens, occlusion of the pupil, and keratoconus.

In performing *optical iridectomy,* a small incision (3 to 4 mm.) is made in the cornea, 2 mm. from the limbus, the iris drawn out with a Mathieu forceps (Fig. 105) or the blunt hook (Fig. 108), and its pupillary portion excised, making as *small* a coloboma as is practicable (Fig. 113). The best position for the artificial pupil is *downward and inward;* but when there is a corneal opacity, the site must correspond to the most transparent portion of the cornea. The effects of optical iridectomy are often disappointing; hence, before operating, it is well to dilate the pupil and, by applying a stenopæic slit held in different positions, to

ascertain whether there is an improvement in sight under these circumstances.

Sclerotomy (*Incision Through the Sclera*) is sometimes performed for the cure of glaucoma, but it is considered *inferior to iridectomy*. It may, however, be a useful procedure in cases in which iridectomy cannot be satisfactorily performed, or in which a relapse occurs after iridectomy has been done once or twice. The incision in the sclera is made in two situations: in front of the iris (anterior sclerotomy), and behind the ciliary body (posterior sclerotomy).

In Anterior Sclerotomy, an incision is made with a Graefe knife, 1 mm. behind the limbus, similar to that made in iridectomy, but the middle third is left uncut and forms a bridge connecting sclera and cornea.

In Posterior Sclerotomy, an incision (1 mm. deep) is made through the sclera into the vitreous with a Graefe knife. The site usually selected is between the external and inferior recti muscles; the cut must not approach the cornea nearer than 7 mm., so as to avoid endangering the ciliary body. This operation is also performed in detachment of the retina (in which case the puncture is made over the separation), and as a preliminary step in the removal of foreign bodies from the vitreous.

Secondary Glaucoma is the name given to those cases in which increased tension and other symptoms of glaucoma are developed as a result of some other ocular disease or injury. The clinical picture varies with the disease which it complicates. The consequences are the same as in primary glaucoma.

The ocular affections which are most frequently followed by secondary glaucoma are: Ulcers or wounds of the cornea with prolapse of iris, corneal cicatrices and staphylomata with incarceration of the iris, iridocyclitis, uveitis, chorioiditis and myopia of high degree, total posterior (ring) synechia, dislocation of the lens, traumatic cataract

(swelling of the lens), the operations of extraction, needling of the lens and discission of secondary cataract, intraocular tumors, and foreign bodies in the eye. In old persons with arterio-sclerosis, a form of secondary glaucoma with retinal hemorrhages is seen, and is known as *hemorrhagic glaucoma.*

The *treatment* depends upon the primary disease. We endeavor, if possible, to *remove the cause.* Hemorrhagic glaucoma does not respond favorably to treatment; iridectomy is liable to be followed by an aggravation of symptoms; the other agents used in glaucoma may be tried, but are usually of no benefit.

Congenital Glaucoma (Hydrophthalmos, Buphthalmos) is a disease of *early childhood*, either congenital or developing in infancy and usually involving *both eyes.* There is an *increase of intraocular tension* which, on account of the yielding character of the sclera at this period of life, causes *marked enlargement of the eyeball.* The cornea is enlarged and bulging, and either remains clear or becomes clouded; the anterior chamber is very deep; the pupil is dilated, and the iris atrophied and tremulous; the sclera is thinned and bluish, owing to the uveal pigment showing through; the disc is deeply excavated. The disease *progresses slowly.* Though in some cases it comes to a spontaneous stop with the preservation of moderately good vision, it generally leads to *blindness.* The *prognosis is unfavorable.* As a rule *treatment* is of no avail; since, however, a few cases have been benefited by iridectomy, sclerotomy, repeated paracentesis of the anterior chamber, and myotics, these measures should be tried.

CHAPTER XVI.

DISEASES OF THE VITREOUS.

Anatomy.—The vitreous is a *transparent, colorless* mass, of soft *gelatinous* consistence, which fills the posterior cavity of the eyeball behind the lens. Its outer surface presents a thin, structureless covering, the *hyaloid membrane.* The vitreous is traversed from the optic disc to the posterior capsule of the lens by a canal, the *hyaloid canal,* serving as a lymph channel in the developed eye, and containing the hyaloid artery during fœtal life. In structure the vitreous consists of a *transparent network,* in the meshes of which are *clear liquid* and round and branching *cells,* probably emigrated white blood-corpuscles. The vitreous has no blood-vessels, but receives its nourishment from the surrounding tissues, the chorioid, ciliary body, and retina.

Muscæ Volitantes is the term employed for the appearance of *spots before the eyes, without appreciable structural change* in the vitreous or other media. They are caused by the shadows cast upon the retina by the cells normally found in the vitreous, and are present in all eyes under certain circumstances, such as exposure to a uniform bright surface, or in looking through a microscope. They are found more frequently in *errors of refraction* (especially *myopia*), and temporarily during *digestive derangements.* They occur as grayish shadows, which move with changes in the position of the eyes, having the shape of dots or globules, frequently collected into strings; they may have any shape. They are *annoying* and sometimes alarm the patient, but are of *no importance,* and do not affect the

acuteness of vision. The *treatment* consists in correcting any error of refraction, or in relieving the disturbance of digestion. They are often obstinate and persist until the patient ceases to look for them and thus forgets their existence.

OPACITIES OF THE VITREOUS.

These are quite *common*. They may occur as a consequence of *changes in the vitreous itself*, but usually they are the result of disease or of hemorrhages from the *neighboring structures*—ciliary body, chorioid, and retina. They vary in number, shape, and size:

(1) A *diffuse cloud or a dust-like haziness* often accompanies cyclitis, chorioiditis, irido-chorioiditis, and retinitis; when dust-like it is suggestive of syphilitic chorioretinitis and iridocyclitis.

(2) The opacities may occur in the form of dots, flakes, threads, or membranous masses, the result of *exudations or hemorrhages*.

(3) Sometimes extensive *membranes* are met with, which are attached to the retina and provided with blood-vessels; these are supposed to result from chronic retinal disease, called *retinitis proliferans*.

(4) Occasionally small glistening opacities are found in degenerated eyeballs and in some which are normal in other respects, especially in old persons; they fall in a silvery shower when the eyeball is moved; they are usually crystals of cholesterin in a fluid vitreous, and are known as *synchysis scintillans*.

Symptoms.—There is more or less *disturbance of vision*, depending upon the situation, size, and density of the opacities. The *opacities* are most frequently *movable*, indicating a fluid vitreous (*synchysis*), the result of disease of surrounding parts. On this account, the visual disturbance may vary according to the part of the vitreous occupied by

the opacity, and the patient may be able to move the eyeball in a certain way so as to throw the opacity out of the line of sight. *Fluid vitreous* gives rise to diminished tension, often a tremulous condition of the iris, and may predispose to detachment of the retina.

Diagnosis is made with the *ophthalmoscope at a distance.* The vitreous opacities appear as *dark spots* upon a red ground, when the eye is moved in various directions. When faint, the opacities are best seen with *diminished illumination.*

Prognosis *varies* with the size, density, and nature of the opacity. Syphilic opacities and small hemorrhages frequently clear up when treated early. Others become smaller and less dense after a time. A great many are permanent.

Treatment.—*Anti-syphilitic* treatment is indicated in specific cases. In others, small doses of *potassium iodide and mercury* may be of service. Diaphoretics and cathartics are sometimes employed. *Subconjunctival injections* of normal salt solution (0.6 per cent.) may be useful.

HEMORRHAGES INTO THE VITREOUS.

These usually come from the *chorioidal vessels* and produce *opacities* of small or large size, causing the symptoms of opacities of the vitreous. When *small,* they have a *red color* as seen with the ophthalmoscope; when *large,* no red reflex can be obtained and the *pupil* appears *black.* The smaller hemorrhages are often absorbed; the larger ones frequently leave dense membranous masses. They occur after injuries, after operations upon the globe, in chorioiditis, myopia of high degree, and retinitis; they are not uncommon in old persons with atheromatous arteries. Sometimes they are found in the young without discoverable cause, and in such cases they may recur repeatedly. The exciting cause is often a strain of some sort, such as

a cough. *Treatment* consists in absolute rest, bandage to the eyes, treatment of the neighboring ocular affection, or of the general condition.

FOREIGN BODIES IN THE VITREOUS.

The accidental entrance of a piece of wood, glass, or metal usually causes *severe inflammation and destruction of the eyeball from iridocyclitis or panophthalmitis.* Occasionally such a foreign body remains quiescent and encysted, but even in such cases there is danger of subsequent inflammation. If the case is seen early, an attempt should be made to extract the foreign body, its location being determined with the ophthalmoscope or the *x*-rays.

Magnet Extraction.—In the case of particles of *iron or steel*, the electro-magnet offers a good prospect of success. The magnet should be introduced through the original opening in the globe or through a meridional opening in the sclera. In most cases, the foreign body is found in the *lower portion of the vitreous* cavity. When the case is seen early, before there is clouding of lens and vitreous, the *ophthalmoscope* is valuable in locating the foreign body; later the *x-rays* may be used. The magnets used for this purpose are of three kinds: (1) Strong permanent magnets useful in the anterior portion of the eyeball; (2) portable electro-magnets, the points of which are introduced into the eye; (3) the large, stationary, Haab electro-magnet, which is intended to draw out the particle of iron through the wound of entrance or to draw it around the lens into the anterior chamber, from which cavity it can be removed. Even after successful extraction, it is only in a minority of cases that useful vision is preserved, *destructive inflammation* frequently supervening after the foreign body has been liberated.

Persistent Hyaloid Artery.—The hyaloid artery usually disappears entirely during the first year of life. Occasion-

ally a greater or lesser remnant persists during life. This can be seen with the ophthalmoscope, as a *grayish cord or thread*, which arises from the optic disc and stretches into the vitreous, with a free extremity or occasionally attached to the posterior pole of the lens. Rarely, the hyaloid canal is abnormally dense and is visible as a grayish, tubular cord extending from disc to lens.

CHAPTER XVII.

DISEASES OF THE LENS.

Anatomy and Physiology.—The *crystalline lens* is a *transparent*, colorless body, *bi-convex* in shape, suspended in the anterior portion of the eyeball, between the aqueous and the vitreous chambers. It presents an anterior and a posterior surface, the latter being the more curved, an anterior pole, a posterior pole, and a rounded circumference, the equator. It is devoid of blood-vessels except in fœtal life, its nourishment being derived from the ciliary body. It is enclosed in a transparent *capsule*, and held in position by its *suspensory ligament*. The adult lens consists of a peripheral portion, the *cortex*, and a central part, the *nucleus*. The cortex is semi-solid, softer than the nucleus, and colorless; the nucleus is harder and has a yellowish tint; there is, however, no sharp limitation, the transition being gradual. The nucleus increases in size with advancing years, and the cortex diminishes in proportion; in old age the entire lens is of the consistence of the nucleus and is hard and unyielding; this change is known as *sclerosis*.

In structure the lens consists of *concentric laminæ* formed of long, *hexagonal fibres*, the edges of which are connected by a cement substance, leaving fine lymph channels. The fibres either start or end along *Y-shaped or stellate figures*, the lines of which radiate from the anterior and posterior pole to the equator, each fibre encircling the latter; the septa corresponding to the branches of the stellate figure divide the lens into *sectors*. These stellate and Y-shaped

figures can often be recognized in the adult lens by oblique illumination.

The capsule of the lens is a thin, homogeneous, elastic membrane which covers the lens, being known as the *anterior capsule* in front, and as the *posterior capsule* behind. The anterior capsule is the thicker, and its posterior surface is lined by a layer of cuboidal epithelium from which the lens fibres are formed.

The suspensory ligament of the lens is a delicate membrane, extending from the ciliary body to the lens capsule. It covers the inner surface of the ciliary body from the ora serrata to the apices of the ciliary processes, and then passes to the lens, dividing into three layers attached respectively to the anterior capsule, the equator, and the posterior capsule. Between these layers and the equator of the lens is a triangular space known as the canal of Petit; it is in communication with the posterior chamber by means of slit-like apertures between the fibres of the anterior portion of the suspensory ligament.

The function of the lens is to focus rays so that they form a perfect image on the retina. To accomplish this, the refractive power of the lens must change with the distance of the object, according to whether the rays are parallel or divergent. This alteration in the refractive power of the lens is known as *accommodation*, and is produced by a change of shape mainly affecting its anterior curvature.

The lens presents *variations* in physical characteristics at *different periods of life*. *In the fœtus*, it is nearly spherical, slightly reddish, and softer than at a later period. *In the adult*, its anterior surface is less convex than the posterior, and its substance is firmer. *Sclerosis*, which consists of a process of toughening, due chiefly to loss of water, begins in the centre of the lens in childhood and advances slowly until adult life, after which its progress is more rapid, increasing the size of the nucleus at the expense of the cortex. *In old age*, the lens increases in size, is flattened, and as-

sumes a yellow tinge, becoming tougher and less transparent; this process of sclerosis accounts for the *gray reflex* seen in the pupil of the aged, which may be mistaken for cataract (*senile reflex*); it also explains the inability on the part of the lens of advanced years, to change its shape for the purposes of accommodation (*presbyopia*).

CATARACT.

A cataract is *any opacity of the lens or of its capsule.*

Varieties.—Cataracts may be divided into:

1. *Primary* when independent of any other ocular disorder.

2. *Secondary or Complicated,* when accompanying or following some other disease of the eye, such as glaucoma, uveitis, etc. The name secondary cataract is also given to the opacity resulting in the *remains of the lens capsule* or lens substance after cataract operations; *after-cataract* is, however, a better term for this form.

Cataracts are divided according to the *part of the lens involved into:*

1. *Lenticular* when situated in the substance of the lens.
2. *Capsular* when affecting the capsule.
3. *Capsulo-lenticular* when involving both lens and capsule.

They are also known as

1. *Partial,* when limited to some part of the lens.
2. *Complete,* when they involve the whole lens.
3. *Stationary,* when they remain incomplete.
4. *Progressive,* when they spread and tend to affect the whole lens.

Stationary Cataracts may be divided into:

1. *Anterior polar.*
2. *Posterior polar.*
3. *Lamellar.*
4. *Various uncommon forms.*

Progressive Cataracts may be divided into:

1. *Senile* { Cortical. / Nuclear.
2. *Congenital and Juvenile.*
3. *Traumatic.*

In patients *under thirty-five* all cataracts are of *soft* consistence throughout and *white* in color; such cataracts have no hard nucleus and are known as *soft cataracts. After this period,* the nucleus becomes *hard* and of a *yellowish* tint, and the lenticular opacity is known as *hard cataract.*

Etiology.—According to etiology, cataract may be classified as:

1. *Congenital,* due to faulty development or intra-uterine inflammation of the eye. To this class belong the anterior and posterior polar, lamellar, and occasionally complete cataract.

2. *Senile;* this is the *most common* form. It usually appears after the age of fifty. The real cause is unknown. Heredity has some influence.

3. *General Diseases:* diabetes and less frequently nephritis, gout, and general arterial disease.

4. *Traumatism,* by the production of an opening in the capsule, thus allowing the lens to absorb aqueous humor; occasionally by mere concussion.

5. *Ocular Diseases,* causing complicated or secondary cataract; the most common examples are severe forms of ulcerative keratitis, iridocyclitis, chorioiditis, myopia of high degree, glaucoma, and detachment of the retina.

Symptoms.—There is (1) *diminished acuteness of the vision,* depending upon the situation and the kind of cataract. It is greatest when the opacity is central and diffuse, and least when the cataract is peripheral. When central, the patient sees best in dim light—with dilatation of the pupil. The interference with vision increases with the progress of the cataract, until finally there is mere perception of light. (2) The patient complains of *seeing spots*

which occupy a fixed position in the field. (3) Occasionally there is annoying diplopia or polyopia, due to *irregular refraction* of the lens. (4) *Myopia* often develops during the early stages, due to increased density and refractive power of the lens; in his manner the patient may be able to discard his reading-glasses for the time; this condition is popularly known as "*second sight.*"

Physical Signs.—There are *no inflammatory symptoms.* Examination by *oblique illumination* will show a *grayish or whitish opacity* on a black ground, and with the *ophthalmoscope* at a distance, a *black opacity upon a red field.* The pupil should be *dilated,* especially in the incipient stage. During the stage of swelling of complete cataracts, the anterior chamber is reduced in depth.

PROGRESSIVE CATARACTS.

SENILE CATARACT.

Senile or Simple Cataract is the *most frequent* form of cataract. It is *quite common after the fiftieth year;* occasionally it is seen as early as forty. Almost always *both eyes* are involved, but generally one in advance of the other. The opacity may begin either in the cortex (*cortical,* Fig. 114), or in the nucleus (*nuclear,* Fig. 115). As a rule, senile cataracts begin in the *cortex* and the nucleus remains transparent throughout the process; a pure nuclear cataract is uncommon. The *time required for full development varies* greatly; it may ripen completely in a *few months* or may require *many years;* it may become stationary at any stage of its progress.

The Stages of Cataract.—There are *four stages:*

Incipient Stage.—The opacity most frequently begins as *streaks* which extend from the *periphery of the cortex,* where they are wider, *to the centre* of the lens, where they narrow *like the spokes of a wheel* (Fig. 114); the periphery is af-

fected first. These streaks appear *grayish by oblique illumination*, and *black* when seen *with the ophthalmoscope.* Between these sectors the lens is transparent. Less frequently, senile cataract begins with dot-like or cloud-like opacities situated in any portion of the lens; sometimes the portion immediately surrounding the cortex becomes opaque (and exceptionally the nucleus itself), constituting so-called *nuclear cataract* (Fig. 115); the last form causes relatively great visual disturbance. Cataracts sometimes remain *stationary* in the incipient stage, with little impairment of vision. Hence it is often wise not to alarm the patient by acquainting him with his condition, at the same time communicating the knowledge to a relative, for our own protection.

A *B* *C*

Fig. 114.—Senile Cortical Cataract. *A*, Seen with oblique illumination; *B*, section of the lens; *C*, seen with the ophthalmoscope.

2. *The Stage of Swelling* (*Maturing Stage*).—The lens absorbs fluid, *swells*, and by pushing the iris forward, *reduces the depth of the anterior chamber.* It appears *bluish-white*, shining, and presents distinctly the markings of the *stellate figure.* During this stage, the *iris casts a shadow* upon the lens when the eye is illuminated from the side, since the superficial portion of the lens is still transparent, and. hence the opaque layer is some distance behind the iris.

A *B* *C*

Fig. 115.—Senile Nuclear Cataract. *A*, Seen with oblique illumination; *B*, section of the lens; *C*, seen with the ophthalmoscope.

3. *Mature Stage.*—The lens loses most of its fluid, *shrinks* somewhat, and becomes *perfectly opaque* and of a *dull gray, or amber* color, the *stellate markings* still being recognizable. The *anterior chamber* regains its *normal depth*, and

there is *no shadow* thrown by the iris on the lens with focal illumination. Occasionally, the entire lens is changed into a hard, dark-brown mass (*black cataract*). In this stage, the cataract can easily be separated from the capsule of the lens; it is then said to be "*ripe*" for operation, since it can be extracted without leaving any portion of the cortex behind, thus diminishing the chances of subsequent opacity (after-cataract).

4. *Hypermature Stage.*—The cataract may continue in the mature stage for a long time. If changes continue, the surface of the lens *loses its radial markings* and becomes *homogeneous*, or presents irregular spots. The cataract may continue to lose water, and thus a *shrunken*, dry, flattened mass results (*shrunken cataract*), with some deepening of the anterior chamber. Or, the cortex may become soft, liquid, and milky, and the nucleus sink to the bottom of this fluid (*Morgagnian cataract*), the cataract appearing white with a brownish coloring below. Very old hypermature cataracts often present the deposit of *cholesterin* or of *lime* salts; the latter change (*chalky cataract*) is found chiefly in complicated cataracts. The anterior capsule may become thickened and opaque (*capsulo-lenticular cataract*). The lens (and iris) may become *tremulous* through stretching of the suspensory ligament. For these reasons, operation upon overripe cataract is less favorable and more difficult than during the mature period.

Pathology.—Senile cataract results from *shrinkage of the nucleus together with the lens fibres* and presence of *fluid* in the spaces thus created. The lens fibres then *swell*, become *cloudy*, and *disintegrate*. The *nucleus* usually remains *unchanged*.

Treatment.—*Extraction* of the lens by operation is the *only means* of relieving a patient of senile cataract; discission is applicable only to cataracts of the young. No medicinal treatment, whether local or constitutional, is of curative value. *In the incipient and maturing stages* the

eyes should be *rested* as much as possible, *correcting lenses* be worn if an error of refraction exists, deranged conditions of the system looked after, and *neighboring ocular disease* be *treated.* The patient should present himself for examination from time to time. In cases in which the opacity is central, sight may be improved temporarily by the instillation of a weak solution of *atropine* ($\frac{1}{2}$ gr. to $\overline{3}$ i.) to cause mydriasis and enable the patient to see through the peripheral, transparent portion of the lens.

The most favorable time for extraction of senile cataract is when the lens is *completely opaque* and there is no shadow thrown by the iris—*i.e.*, when the cataract is *ripe.* If operated upon before this time, the lens is not always removed cleanly and some transparent cortex is apt to adhere to the capsule and be left behind; this becomes opaque subsequently, and is absorbed slowly, or an after-cataract develops necessitating another operation—discission; besides, the remains of cortex after extraction tend to produce irritation and interfere with smooth healing.

As a general rule, we operate when the cataract of one eye is *complete,* and the other has progressed far enough to cause considerable *interference with vision.* But there are a number of exceptions to this rule: For instance, when the occupation and circumstances of the patient are such that being unable to work, he cannot wait for the cataract of the first eye to become ripe; or when the cataract shows signs of hypermaturity before the second eye is very much affected. Removal of both cataracts should never be performed at one sitting. When both eyes are affected, useful vision may be abolished before either cataract is ripe. *Artificial ripening* is sometimes resorted to; this is accomplished by preliminary operations consisting either of needling (*discission*), or of gentle *massage* applied to the lens directly or through the cornea. An incision is made through the periphery of the cornea and the aqueous humor allowed to escape, so that the cornea falls against the lens;

then the cornea over the pupil is stroked with a smooth instrument, or the spatula or spoon may be introduced into the aqueous chamber and applied directly to the anterior capsule. Such direct or indirect massage may be done with or without an accompanying iridectomy. Following such operations, the lens becomes opaque after a few weeks, and can then be extracted. Ripening operations are, however, not always reliable nor entirely free from danger; it is now generally considered *safer and better to remove the immature cataract* than to resort to such artificial ripening. Many operators regard the condition of immaturity in a cataract as adding very little to the risks of extraction.

Extraction may be performed *with* (*Combined Extraction*) *or without* (*Simple Extraction*) *an iridectomy;* the question as to which is the better operation has been much discussed. *The simple operation* (without iridectomy) is probably now performed in the majority of cases; its disadvantage is the danger of *prolapse of the iris. The combined extraction* (with iridectomy) is indicated when the iris interferes with the easy delivery of the lens, or protrudes during the operation and cannot be reduced, when the lens is very large, when we suspect that the patient may not behave well after the operation, or when any ocular complications exist. In ordinary cases, *simple extraction* is preferred, since it leaves a *round pupil*, without the optical defects of a coloboma, and hence an improvement in vision and appearance. Some operators perform a *preliminary iridectomy*, and an extraction several weeks later, as a means of lessening the dangers of extraction when complications are feared.

Monocular cataract is not generally removed, since owing to the difference in refraction, the eyes will not work together. Extraction may, however, be performed in such cases for cosmetic effect, to prevent hypermaturity, and to extend the field of vision on the affected side.

Aphakia.—After the extraction of cataract, the patient is compelled to wear *strong convex glasses*, since as a result

of loss of the lens (*aphakia*), there is a *high degree of hyperopia and absence of the power of accommodation.* This hyperopia amounts to about 10D With it there is usually considerable *astigmatism* (2 to 3D), generally "against the rule." In an average case, therefore, a convex spherical lens of about 10D, combined with a convex cylinder of 2 to 3D, must be worn for *distant vision;* to this *spherocylinder* an additional convex sphere of 3 or 4D must be added for *reading.* Any previous error of refraction will, of course, modify this correcting lens. Glasses should not be prescribed until all signs of irritation have disappeared —generally at the end of a month. Changes in refraction may continue for several months. *The aphakial eye* presents, besides hyperopia and loss of accommodation, a *deep anterior chamber* and usually a *tremulous iris;* the images normally seen on the anterior and posterior surfaces of the lens are absent.

Prognosis.—A *favorable result and useful vision* follow cataract extraction in the great majority of uncomplicated cases (ninety-five per cent.); there is very often excellent sight, and occasionally perfect vision. *The prognosis* is dependent not only upon *skilful operation,* but upon *careful selection,* and upon exclusion of those complicated cases which cannot be improved by an operation, no matter how successful. Hence it becomes important to diagnose properly the condition of the other ocular structures, and especially that of the *retina.* This is done by *testing the field of vision* with the candle for *light perception* and *light projection.* There should be a good field and good perception and projection of light.

Projection is tested by throwing light from the mirror of the ophthalmoscope upon the upper, lower, inner, and outer portions of the pupil; there is good projection, if the patient is able to state correctly the direction from which the light comes. This test may also be applied with the lighted candle made to approach the eye from various directions, at a distance of one metre and also at a greater distance—

three to four metres. Although the cataract be fully matured, there should be good perception of light, even with faint illumination; fingers can frequently be counted at several inches

CATARACT EXTRACTION.

Indications.—The operation of extraction is indicated for (1) the removal of all *senile cataracts* which are considered fit for operation; (2) soft cataracts after the age of fifteen (sometimes before this period); (3) soft cataracts which have been needled, or traumatic cataracts when glaucoma intervenes or to expedite cure; and (4) occasionally complicated cataracts.

The following description applies to the method of performing *simple extraction* (without iridectomy), as most commonly done.

Instruments Required: (1) An eye speculum (Fig. 116); (2) a fixation forceps (Fig. 117); (3) a narrow Graefe knife (Fig. 118); (4) a cystotome, straight (Fig. 119); or bent (Fig. 120); if bent, one is required for the right and one for the left eye; (5) a Daviel spoon (Fig. 121); (6) a Knapp metal spatula and probe (Fig. 122); (7) a wire lens scoop (Fig. 123). Since it may be necessary to do an iridectomy, we must have ready, (8) curved iris forceps (Fig. 104); and (9) curved iris scissors (Fig. 106).

Operation.—1. *The Corneal Section.* Local anæsthesia by *cocaine or holocain* is generally used, rarely a general anæsthetic. The operator stands behind the patient (if ambidextrous) and inserts the eye speculum; the patient looking down, he seizes the eyeball near the lower margin of the cornea with the fixation forceps held in one hand, and makes the corneal section with the other. This section comprises a *little less than one-half of the circumference of the cornea* and is in the plane of its transparent margin. The *Graefe knife* is thrust into the corneal margin just above the horizontal meridian, traverses the anterior cham-

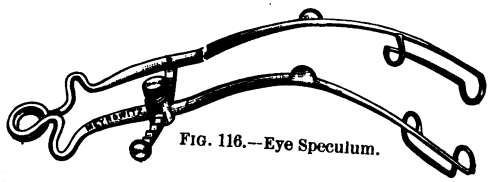


FIG. 116.—Eye Speculum.

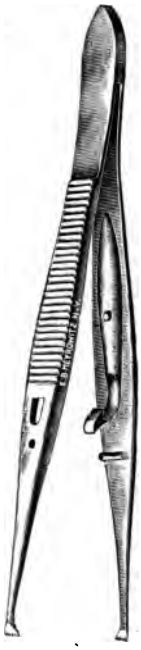


FIG. 117.—Fixation Forceps.

FIG. 118.—Graefe Knife.

FIG. 119.—Straight Cystotome.

FIG. 120.—Bent Cystotome.

FIG. 121.—Daviel Spoon.

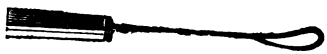


FIG. 123.—Wire Lens Scoop.

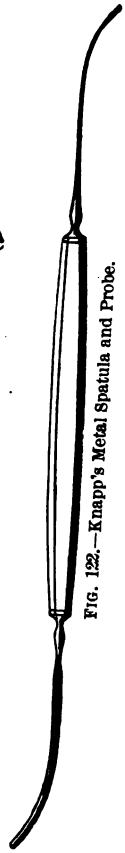


FIG. 122.—Knapp's Metal Spatula and Probe.

FIGS. 116–123.—Instruments Required for Cataract Extraction.

ber, and emerges at a point opposite the puncture (Fig. 124). Pushing the knife forward and cutting upward by a to-and-fro movement, the section is completed in the same plane, close to the iris, terminating at the upper margin of the cornea, where a small conjunctival flap is usually made. If the operator is not ambidextrous he must stand in front of the patient when operating on the left eye, so as to hold the knife in the right hand.

2. *Opening the Capsule* (*Capsulotomy*).—The cystotome is introduced flatwise into the anterior chamber from the temporal side, its point is turned toward the capsule, and this is cut gently and

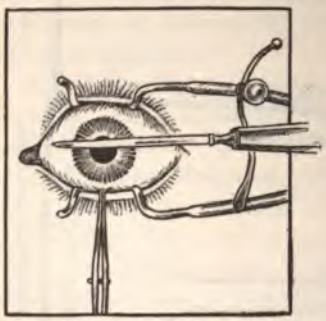


FIG. 124.—Corneal Section in Cataract Extraction.

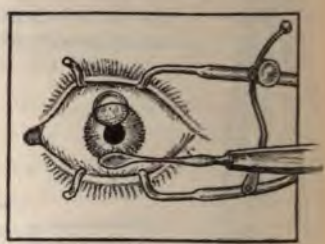


FIG. 125.—Delivery of the Lens in Cataract Extraction.

without pressure. There are many different methods of opening the capsule. It may be cut at the periphery (Knapp) by pushing the end of the cystotome beneath the upper part of the iris, turning it and making an incision concentrically with the corneal margin; or the incision may be T-shaped, or A-shaped, or +-shaped.

3. *Delivery of the Cataract.*—The speculum and fixation forceps are removed, and the lens is expelled by pressing gently upon the lower part of the cornea toward the centre of the globe, with the back of a Daviel spoon. This causes gaping of the section, in which the lens presents (Fig. 125). After a great part of the lens has passed through the cor-

neal wound, the spoon is made to follow up the lowest part of the cataract, which is thus delivered and received upon the wire loop. If the pupil is unyielding, and the iris impedes the exit of the lens, it may be pressed backward with the wire loop or a special iris retractor.

4. *Cleansing ("Toilet") of the Wound.*—A few drops of an antiseptic solution are instilled, the lids closed for a few minutes, after which the eye is inspected. If there are any cortical remnants, these should be removed by rubbing the edge of the lower lid upward over the cornea and by stroking with the spatula; blood clots may be expelled in the same manner; the lips of the wound must also be freed from lens particles with the spatula. Care should be taken that the lids do not touch the corneal wound. Sometimes the anterior chamber is irrigated with a special, delicate syringe, using sterilized saline solution (0.6 per cent.); but as a rule this is found unnecessary. If the iris fails to regain its natural position, we exert gentle pressure upon the lower margin of the cornea, so as to cause the wound to gape and thus disentangle the iris; if this does not succeed it will be necessary to introduce the spatula into the anterior chamber, and smooth out the iris until the pupil becomes round and central. If we do not succeed in this, and the iris shows a tendency to become displaced again or to prolapse, a small portion is excised. The patient is now allowed to count fingers, and the eye again inspected with oblique illumination. The conjunctival flap is next adjusted, the eye washed out with a few drops of antiseptic solution, and the lids are closed.

5. *Dressing.*—The dressing varies with different operators. Most operators cover the lids with gauze and cotton soaked in an antiseptic solution, upon which a greater or lesser quantity of dry cotton is placed, and then confine these with a binocular bandage. Some surgeons retain the dressings by strips of isinglass plaster. The lids are sometimes closed by a piece of isinglass plaster without any

other dressing. Sometimes various protective covers (aluminum, wire, mica, stiff cloth) are used to prevent injury to the operated eye, or the patient's hands are tied for the same reason.

After-treatment.—The patient is directed to lie quietly upon his back; an anodyne is usually advisable. After twenty-four hours he may change to the side of the unoperated eye. His food should be fluid. The bowels need not be emptied artificially for three or four days; if the patient has a movement before this, he must be cautioned not to strain. The wound is inspected after twenty-four hours; if any prolapse of iris has occurred, it is excised. If the pupil is central and round, atropine is instilled after the second or third day. On the fourth or fifth day the unoperated eye may be left free, and the patient may sit up in bed for an hour or two; after two weeks nothing but smoked glasses need be worn.

Modifications in the Operation.—A great many operators make a small iridectomy in every cataract extraction (*Combined Extraction*). There are a great many modifications in the situation of the section.

A small corneal section is made for the removal of *soft* and *traumatic* cataracts, and cataract masses produced by needling; the operation is then known as

Linear Extraction, and is performed as follows: With the lance-shaped knife an incision about 5 mm. wide is made near the margin of the cornea, and then the capsule is torn with the cystotome. The soft lens masses are evacuated by depressing the posterior lip of the wound with the wire loop. A small iridectomy is sometimes combined with this operation.

The Complications of Cataract Extraction include loss of vitreous, dislocation of the lens, insufficient opening in the cornea or capsule, wounding the iris, prolapse of the iris, incomplete evacuation of the cataract, and intraocular hemorrhage.

The Complications in the Healing-Process include prolapse of the iris, striated keratitis, glaucoma, iritis, iridocyclitis, cyclitis, suppuration of the wound, panophthalmitis, and intraocular hemorrhage.

CONGENITAL COMPLETE AND JUVENILE COMPLETE CATARACT.

These forms of cataract are *infrequent*. The lens is uniformly *white or bluish-white*, or it may have a pearly lustre. It is *always soft*. Sometimes it is fluid and milky. These forms of cataract may occur in eyes which are otherwise perfectly healthy, or they may be complicated cataracts, with changes in the retina, chorioid, or optic nerve. One or both eyes are affected. The congenital complete cataract is due to a disturbance of development or to some intrauterine ocular inflammation. The complete cataract of *young people* (*juvenile*) may be due to heredity, or arise without known cause; in some cases, there is a history of previous convulsions.

Treatment consists in *discission* (*needling*); this should be done as *early as possible*, so that the absence of sight will not interfere with the development of the retina, and cause amblyopia. The needle operation must be repeated a number of times; sometimes there are remains of the lens which do not become absorbed and must subsequently be removed by extraction. Semifluid cataracts are removed by small incision into the cornea and lens capsule (linear extraction), after which they are pressed out.

DISCISSION OF THE LENS (NEEDLING).

Indications.—(1) In zonular, congenital complete, and juvenile complete cataracts (*soft cataracts*), previous to the fifteenth year; (2) preliminary to extraction in cases of high degree of *myopia*; (3) as a means of *ripening* senile cataract. Discission is also used for dividing *after-cataract*.

Operation.—In very young children a *general anæsthetic* is required; in others, *local anæsthesia* is sufficient. The *pupil* must be *dilated*. The speculum is introduced and the eyeball steadied with the fixation forceps. A knife-needle (Fig. 126) is thrust through the outer portion of the cornea and then through the capsule of the lens, making two cuts, each about 4 mm. in length, at right angles to each other. These cuts must be superficial, especially if this is the first operation, so that there will not be too rapid swelling of the lens. The lens substance may be broken up a little by rotating the needle. After some of the swollen lens matter has been absorbed (several weeks), the operation must be repeated; at the second operation the discission may be deeper and bolder. At the last of the several operations, the incision must include the posterior capsule.

FIG. 126. — Knapp's Knife-Needle.

After-Treatment. — There is usually very little reaction. The pupil must be kept dilated with atropine. The lens substance swells, protrudes through the opening in the capsule, and pieces fall into the anterior chamber and become absorbed. Usually three operations are required. The entire duration of treatment is several months.

Complications.—*Rapid and extensive swelling* of the lens may cause secondary *glaucoma requiring removal of the lens* by linear extraction, with or without iridectomy. A bold discission is sometimes done, with a view of extracting the lens a few days afterward, as soon as there is marked swelling; this is the usual procedure when the lens is removed in high degrees of myopia. *Iritis* may occur after discission, occasionally iridocyclitis, and very rarely loss of the eye.

After discission of soft cataracts, and in fluid or semi-*fluid cataracts*, the *Suction Method* is occasionally used: A

small corneal wound is made and the capsule lacerated; by means of a tube the lens matter is sucked out, either by mouth or suction-syringe. This method is not in general use.

TRAUMATIC CATARACT.

This form of cataract is the result of a *perforating wound of the lens capsule;* occasionally it ensues after contusions of the eyeball, without perforation (concussion cataract), though probably a rupture of the capsule occurs in such cases. Within a few hours after the injury the lens becomes *cloudy* at the seat of the wound from absorption of aqueous humor, and *swells;* opaque and swollen *lens substance protrudes* through the wound in the capsule and often falls into the anterior chamber; the swelling and clouding continue until, after a few days, the *entire lens has become opaque.* Then the lens substance becomes *absorbed;* in favorable cases in young persons, this process continues until there is *spontaneous cure* with a clear, black pupil. More frequently, however, part of the lens *remains opaque* in the capsule and requires subsequent operation. Occasionally the opacity of the lens remains limited to the injured portion; in some cases such a stationary cataract becomes absorbed. The course described may be less favorable. *Inflammation of other parts* of the eye may result—iritis or iridocyclitis, or when infection occurs, panophthalmitis. The swelling of the lens may cause *iritis* or *glaucoma.*

Treatment.—Immediately after the injury, *absolute rest, iced compresses,* and *atropine* are to be employed. If the rapid swelling of the lens causes inflammation or much *increase of tension,* the cataract should be removed by *extraction.* But if such complications do not arise, it is wiser to *allow absorption to proceed,* and to defer operative intervention until there is no irritation or inflammation, and spontaneous improvement has come to a standstill.

STATIONARY CATARACTS.

Anterior Polar or Pyramidal Cataract.—This lenticular opacity occurs in the form of a *small, round, white opacity*, often *pyramidal* in shape, situated at the *anterior pole* of the lens, beneath the capsule (Fig. 127). It may be *congenital or acquired*. The acquired form originates from an *ulcer of the cornea* in early childhood. Such an ulcer

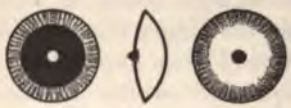


FIG. 127.—Anterior Polar Cataract. *A*, Seen with oblique illumination; *B*, section of lens; *C*, seen with the ophthalmoscope.

FIG. 128.—Acquired Form of Posterior Polar Cataract. *A*, Seen with oblique illumination; *B*, section of the lens; *C*, seen with the ophthalmoscope.

perforates and allows contact and pressure between lens and cornea, setting up an irritation in the anterior capsule which results in a proliferation of the subcapsular epithelium; afterward the anterior chamber is restored. It is sometimes accompanied by a corneal opacity. As a rule it does not interfere with vision sufficiently to require treatment.

Posterior Polar Cataract.—This form may be *congenital* (*capsular*) or *acquired* (*cortical*).

The *congenital* form is a capsular opacity consisting of a *small, round, white* deposit, situated at the posterior pole; with the ophthalmoscope it appears as a black dot upon the red fundus-reflex. It represents the *remains of the hyaloid artery* at the point of attachment to the posterior capsule of the lens. It causes but *trifling interference with vision* and requires no treatment.

The *acquired form* is a *grayish, stellate* opacity of larger size, situated in the *cortical layer* of the lens, at its pos-

terior pole (Fig. 128). It is a form of *secondary cataract* which develops in connection with high myopia, chorioiditis, disease of the vitreous, and retinitis pigmentosa. It remains *stationary* for many years, but is apt *finally to become complete.* In this affection there is *considerable impairment of vision,* caused not only by the cataract, but also by the accompanying disease of the deep structures. It does not admit of treatment.

Lamellar or Zonular Cataract.—This variety of *partial, stationary cataract* is either *congenital* or forms in *early childhood,* and usually affects *both eyes.* It is the *most common form* of cataract *seen in children.* It is sometimes *hereditary,* and often associated with a history of *convulsions* and with the changes of *rickets,* especially in the teeth and bones. It consists of a *gray, disc-like opacity* of the layer *surrounding the transparent nucleus,* with clear cortex on the outside (Fig. 129). When the pupil is dilated, examination by oblique illumination shows a *grayish disc surrounded by clear lens substance;* from the margin of the opacity short striæ are often seen projecting into the surrounding transparent cortex. The cataract is *most dense at the margin of the disc;* this distinguishes it from nuclear cataract. By the use of the ophthalmoscope at a distance, the cataract presents a dark disc surrounded by a zone of red fundus-reflex; the disc is somewhat lighter in the centre than at the periphery, and in the former situation allows some light to pass.

A B C

FIG. 129.—Zonular Cataract. *A*, Seen with oblique illumination; *B*, section of the lens; *C*, seen with the ophthalmoscope.

Lamellar cataract *usually remains stationary,* but occasionally becomes complete. It causes *interference with vision;* the amount may be slight or decided, depending upon the extent and density of the opacity.

Treatment.—When sight is considerably interfered with

we can improve vision by *iridectomy*, by *discission* in the young, or by *extraction* in older persons. *Iridectomy* (small coloboma downward and inward) is indicated when the vision is very materially improved after the use of a mydriatic; its advantages are that the patient does not require strong convex lenses and often retains binocular vision; its disadvantages are the elongated pupil, and some dazzling due to this. Removal of the lens by *discission* or *extraction* is indicated in those cases in which there is little or no improvement in sight after dilatation of the pupil, and when there are indications of progress of the cataract.

Various Uncommon Varieties of Stationary, Partial Cataract are met with. These include (1) *central cataract*, a small, white opacity in the centre of the lens, (2) *fusiform cataract*, a spindle-shaped opacity running from the anterior to the posterior pole, and (3) *punctate cataract*, consisting of a number of very small, white dots variously distributed through the lens. These opacities are usually *congenital*, cause *little interference with vision*, but are often associated with other ocular defects.

COMPLICATED OR SECONDARY CATARACTS.

These accompany or follow other diseases of the eye The most frequent ocular affections which lead to cataract are iridocyclitis, chorioiditis, severe forms of corneal ulcers, glaucoma, retinitis pigmentosa, and detachment of the retina. Such cataracts frequently begin in the *posterior* part of the lens, often have distinctive features, and tend to *degenerate*. It is important to establish the fact that a cataract is complicated when the question of operation presents itself. The *treatment* of complicated cataract is usually *very unsatisfactory* and the *prognosis* is always *less favorable* than in uncomplicated cases. This is because the operation is rendered difficult and the effect on sight disappointing by the complicating ocular disease; many cases *cannot be* operated upon.

AFTER-CATARACT.

This form, often called *Secondary Cataract*, is an opacity found in the situation and plane of the pupil, *after a cataract operation;* it consists of *remnants of lens cortex*, of *proliferation of remaining subcapsular epithelium*, or of *products of inflammation* (new connective tissue). The membrane thus formed may be thin and delicate or thick and tough, and the degree of subsequent diminution in the improvement in sight following the cataract operation will vary accordingly. When due to inflammatory products, the membrane is apt to be thick and the iris adherent.

Treatment consists in *dividing the membrane* (*discission*), after all signs of irritation or inflammation have subsided (two or three months).

Discission for After-Cataract.—If the opacity is thin and delicate it is divided by means of Knapp's *knife-needle* (Fig. 126) introduced through the periphery of the cornea, the pupil having previously been dilated; a T-shaped or +-shaped incision is made, care being taken that the instrument is sharp, and that there is no dragging on the iris or ciliary body for fear of subsequent inflammation. Such membranes are sometimes cut by introducing the knife-needle from behind, through the sclera. *If the membrane is thick and tough*, it may be divided by *two knife-needles*, one entering at each side of the periphery of the cornea, meeting in the centre of the pupil and then separating. The membrane and iris may be cut with the Graefe knife (*iridotomy*, p. 149), or it may be extracted by *irido-cystectomy* (p. 149). Discission of after-cataract is sometimes followed by *glaucoma*, and occasionally by iridocyclitis and suppu[illegible].

LOCATION OF THE LENS.

The lens may be *partial* (*subluxation*) or *complete* (*luxation*).

Symptoms are *disturbance of vision, interference with accommodation, a change in refraction, monocular diplopia, and tremulous iris.* They differ according to whether the displacement is partial or complete. In addition there are *complications and sequelæ* which are often *serious.*

Partial Dislocation (**Subluxation**) may consist of a tilting of one edge of the lens, or of a *lateral displacement*— upward, downward, inward, or outward. In such cases the anterior chamber will be of unequal depth, being increased where the lens is absent. The *convex edge of the lens can usually be seen* (Fig 130) in some part of the pupil, the portion of the latter which is free from lens being particularly black With the indirect method of ophthalmoscopy, the optic disc appears double, one image being seen through the lens and the other through the free pupil. Movements of the eyeball disclose a tremulous condition of the lens and iris (iridodonesis). There are considerable *myopia*, the convexity of the lens being increased through relaxation of the suspensory ligament, and marked *astigmatism*. *Monocular diplopia* is complained of, two images being formed on the retina. The subluxated lens may become *opaque*, and this adds to the visual disturbance.

FIG. 130. — Dislocation of the Lens.

Complete Dislocation (**Luxation**) occurs when the lens is displaced *anteriorly* into the aqueous, or *posteriorly* into the vitreous cavity. In traumatic cases in which there is rupture of the sclera, the lens may lie *beneath the conjunctiva*.

When dislocated anteriorly, the lens is easily recognized If transparent, it looks like a large drop of oil with a curved, golden margin when seen by oblique illumination; the anterior chamber is increased in depth

When displaced into the vitreous, the lens sinks into the lowest part, and either becomes attached to the fundus by

exudation or moves about; when opaque, it can be seen with the ophthalmoscope and sometimes with the unaided eye. The anterior chamber is deep, the iris tremulous, and the pupil very black. The eye is, as in aphakia, in a condition of extreme hyperopia and has lost its power of accommodation.

Complications and Sequelæ. — A *partial* dislocation often *changes* to a *complete* one. When subluxated, the lens may remain clear a long time, but completely dislocated lenses soon become *opaque.* Chorioiditis and iridocyclitis, secondary glaucoma, and even sympathetic ophthalmia sometimes follow. Displacement into the vitreous is tolerated better than anterior luxation.

Etiology.—Dislocation of the lens may be either *congenital or acquired.* In order that the lens can become dislocated there must be some *defect in the suspensory ligament,* such as rupture, stretching, or imperfect development.

The *congenital form* is partial, usually upward, often becomes complete in after-years, is generally bilateral, and often hereditary.

The *acquired forms* are either *traumatic or spontaneous.* Traumatic dislocation is generally the result of contusions. The predisposing cause of spontaneous dislocations is a change in the suspensory ligament seen in fluid vitreous, chorioiditis, and myopia of high degree, detachment of the retina, and hypermature cataract; the exciting cause may be insignificant, such as various straining efforts.

Treatment.—*In partial dislocation,* if no symptoms of irritation are produced, treatment consists in prescribing suitable glasses, usually *strong convex lenses* to correct the refraction of the aphakial portion. When the lens is *dislocated into the anterior chamber* it should be *removed,* by discission in young persons, by extraction in older cases; the lens should first be pierced by a needle to prevent its dislocation into the vitreous, and be removed by a spoon or wire scoop after corneal incision. If *dislocated into the*

vitreous, extraction is indicated but difficult; *strong convex glasses* are prescribed for the aphakia. If inflammatory symptoms arise in a case in which the dislocated lens cannot be removed, an *iridectomy* may be tried; if, in such cases, the eye is sightless, *enucleation* is indicated.

CHAPTER XVIII.

DISEASES OF THE RETINA.

Anatomy.—The retina is a *thin, delicate membrane* which consists, among other parts, of an *expansion of the optic nerve.* It is placed between the hyaloid membrane of the vitreous internally, and the chorioid externally. It *extends forward* to the ciliary body where its termination is called the *ora serrata;* devoid of nerve fibres, simpler and thinner, it is continued over the inner surface of the ciliary body and the posterior surface of the iris. In the living eye, it is *transparent* and of a *purple-red color;* under the influence of light, it is quickly *bleached;* after death, it soon becomes opaque and white. The retina is *connected with the subjacent chorioid* at the entrance of the optic nerve and at the ora serrata; elsewhere it simply lies upon this tunic but is not attached to it. When we detach the retina, the pigment cells which form its outermost layer adhere to the chorioid, and on this account were formerly described as part of the latter.

The *inner surface* of the retina presents in the axis of the eyeball the *yellow spot or macula lutea,* about 1 to 2 mm. in diameter, and in its centre a small depression, the *fovea centralis;* this is the region of *most distinct vision,* and the part of the retina which is made to receive the image when we wish to get an exact impression of an object. About 3 mm. to the inner side of the posterior pole of the eye is a pale, round area, the *head of the optic nerve* (*papilla* or *disc*), corresponding to the point where the optic nerve pierces the retina (Fig. 24). The circumference of the disc

is slightly elevated above the surface of the retina, but the centre presents a *depression*, the *physiological cup or excavation;* here the *blood-vessels of the retina* enter the eye. The ophthalmoscopic appearances of the background of the eye and the distribution of the retinal vessels are given in Chapter III.

The central artery of the retina, accompanied by the corresponding vein, pierces the optic nerve about 2 cm. from the globe, and passes between the bundles of fibres to the inner surface of the retina at or near the middle of the disc. Excepting at the papilla, where minute communications are sometimes found between retinal and ciliary vessels, the retinal arteries have no anastomoses; they are *terminal branches;* hence in obstruction of the central artery there is no compensatory collateral circulation, and blindness results. The retinal vessels lie in the *inner layers;* the external layers are destitute of blood-vessels and are nourished by the adjacent chorio-capillaris. The *fovea has no blood-vessels;* in this situation, the chorio-capillaris is thickened. The blood-vessels are surrounded by lymphatic sheaths forming the lymphatics of the retina.

The *minute anatomy* of the retina is very *complicated.* We distinguish *two kinds of tissue:* (1) *nervous elements*, of which there are *eight layers*, and (2) *supporting tissue* (Mueller's fibres). The supporting tissue comprises the internal and external limiting membranes and numerous fibres serving to keep the delicate nerve tissue in proper position.

Microscopic examination shows the following *layers of the retina*, from within outward: 1. The *membrana limitans interna.* 2. The *layer of nerve fibres*, consisting of the expansion of the fibres of the optic nerve destitute of medullary layer after piercing the eyeball. 3. The *ganglionic layer*, a stratum of *large branching nerve cells.* 4. The *inner molecular layer.* 5. The *inner nuclear layer.* 6. The *outer molecular layer.* 7. The *outer nuclear layer.* 8.

The *membrana limitans externa*. 9. The *rods and cones, the light-perceiving layer*. 10. The *pigmentary layer*, which bounds the retina externally and consists of a single stratum of *hexagonal pigmented cells*.

The *rods* are much more numerous than the *cones*, excepting at the macula where the cones preponderate. *At the fovea* there are no rods, and the *cones*, longer and narrower than elsewhere, are found *exclusively*. In this spot also, *all the layers* of the retina are *much thinner*, there is *no nerve-fibre layer*, and Mueller's fibres are arranged obliquely. The *disc* consists of *optic-nerve fibres exclusively;* it has no other retinal nerve elements and has no power of sight; hence it is called the *blind spot*.

Physiology.—*The action of light changes the visual purple* contained in the outer segments of the rods into a colorless substance. When the eye is in the dark, most of the pigment is stored in the body of the cell and is withdrawn from between the rods. After exposure to light, the pigment granules push their way inward into the processes extending between the rods and cones, and the latter become contracted and shortened. The function of the pigment cells is the renewal of the visual purple of the outer segments of the rods after the bleaching produced by exposure to light.

The *rods and cones*, the *terminal organs of the optic nerve*, receive waves of light which fall upon the retina and convert these vibrations into impulses which are carried by the optic nerves and tracts to the *brain;* here they produce the *sensation of light*. When the image of an object falls upon the macula, there is distinct vision; when it falls upon any other part of the retina, there is indistinct vision. Two points give rise to *separate visual impressions* when their images are at least 0.002 mm. apart, since this represents the diameter of the cones at the fovea; images which are closer than this would only stimulate one cone and consequently create but one visual impression. In other words,

to be seen distinctly, two objects must subtend a visual angle of one minute or more (p. 9).

Images of an object give rise to a *single visual impression* when they fall upon *corresponding retinal areas;* otherwise there are double images. *In binocular vision certain portions of the retina are associated;* thus the upper halves of the retinæ correspond, as do also the lower halves; but the nasal side of one retina corresponds to the temporal half of the other and *vice versa.*

Rays of light impinging upon the retina come from the *opposite side of the field;* thus the upper part of the retina is used for seeing objects in the lower part of the field, the temporal portion of the retina for the nasal part of the field, etc. The *image* on the retina is always *inverted.*

Affections of the Retina may be divided into:

1. *Inflammation,* the various forms of *retinitis:* (1) simple, (2) albuminuric, (3) diabetic, (4) leukæmic, (5) syphilitic, (6) hemorrhagic, (7) purulent, (8) uncommon forms of retinal changes.
2. *Vascular changes:* (1) anæmia, (2) hyperæmia, (3) hemorrhages, (4) embolism, (5) thrombosis.
3. *Pigmentary Degeneration* (retinitis pigmentosa).
4. *Detachment.*
5. *Tumor:* glioma (see chapter on Intraocular Tumors).

RETINITIS.

Inflammation of the retina presents *various clinical types.* There are, however, certain signs and symptoms which are more or less common to all varieties. Retinitis may be (1) *primary,* or (2) *secondary,* when it is an extension of inflammation of neighboring ocular structures. It usually *extends* to both the *papilla and the chorioid.* When the involvement of the entrance of the optic nerve is marked, we speak of the affection as *neuro-retinitis;* when the cho-

rioid is prominently implicated, we call the condition *chorio-retinitis*. The disease may be confined to *one eye;* but since it is generally dependent upon a constitutional factor, it is *almost always bilateral.* It may be acute in course, but as a rule it lasts *many weeks* or even several months.

Subjective Symptoms.—(1) *Diminution in acuteness of vision* varying with the severity and extent of the retinitis, but generally considerable; it may be especially marked at night, constituting *night-blindness.* (2) *Changes in the field of vision;* there may be concentric or irregular contraction, or scotomata. (3) *Alterations in the shape of objects: micropsia,* objects appearing smaller than they really are; *macropsia,* objects appearing larger than normal; *metamorphopsia,* a distortion of the shape of objects, straight lines appearing wavy and bulging. (4) *Diminution of the light sense.* (5) Feeling of *discomfort* in the eyes. (6) *Photophobia* may be present, but pain is rare.

Objective Symptoms.—There are *no external signs;* the objective symptoms are all *ophthalmoscopic: Diffuse clouding* of retinal details, especially in the region of the papilla; *congestion of the disc with indistinctness of its edges; circumscribed exudations* appearing as *soft, white,* or slightly yellow *spots* or patches, discrete or confluent, varying in size, and found principally along the retinal vessels and at the macula; *tortuosity and distention of the vessels,* which may be obscured in parts by swelling and exudation; *hemorrhages* of various shapes and sizes, *rounded* when occurring in the deeper layers, and feathery or *flame-shaped* when superficial.

Course.—The inflammation *may subside* completely and *useful vision* return; or certain *changes may occur* in the retina as a result of *atrophy,* causing considerable *impairment* or absolute *loss of vision.* These *changes* are: *Atrophy of the retina* allowing the chorioidal vessels to become visible; *bright,* white *patches* and *bright dots* replacing hemorrhages or exudation and frequently *pigmented; contraction*

of the vessels, which are bordered by white lines; *atrophy of the disc*, which presents an indistinct outline and a pale, dirty color (*post-neuritic atrophy*). The *prognosis* depends upon the severity of the inflammation, the parts of the retina most involved, and the clinical form of the retinitis.

Pathology.—The changes consist in *congestion*, *œdema*, *exudation* of white blood corpuscles and of fibrin, *fatty degeneration*, and *extravasation of blood*. The white spots are due to exudation of white blood corpuscles and of fibrin, swelling of nerve fibres and cells, and fatty degeneration of the retinal elements and of exudation.

Etiology.—Retinitis occurs occasionally as a local lesion. But *generally* it is merely a manifestation of a *constitutional disease*, such as *nephritis*, *diabetes*, *syphilis*, affections of the *vascular system*, etc.

Treatment.—The *local treatment* consists in *absolute rest* for the eyes, *protection from light*, either by smoked glasses or the darkened room, and the use of *atropine*. *Internally*, we give small doses of *mercury*, also *iodide of potassium*, *diaphoretics*, and sometimes cathartics. In addition, it is of the greatest importance to *treat the constitutional condition* which is the cause of the retinal lesion.

SIMPLE RETINITIS.

This disease, also known as *Serous Retinitis* and *Œdema of the Retina*, is an inflammation of the *superficial layers* of retina, *slight* in degree, and *simple or serous* in type; the evidences of inflammation are limited to *swelling*, *vascular distention*, and occasionally *hemorrhages*. Some authorities regard it, not as a distinct disease, but as the first stage of the more common forms of retinitis; in the latter, the inflammation is of the parenchymatous type and the pathological changes are more extensive, involving the deeper layers of the retina, and are capable of causing greater *destruction*.

The *subjective symptoms* consist of *impairment of vision, distorted* vision, *contraction of the visual field,* and *scotomata.* The *ophthalmoscopic signs* are *hazy picture* of the fundus, especially around the disc, the margins of which are *indistinct; tortuous* and dilated *veins;* the vessels are *hidden* in places by the swelling; and occasionally there are *hemorrhages.*

Many *causes* have been assigned to this form of retinitis, among them *overuse* of the eyes especially with *uncorrected errors of refraction* and with *poor illumination,* exposure to *cold,* exposure to *excessive light* and heat, and *syphilis.* It may be the *first stage of other forms* of retinitis. No assignable cause may be found. When the affection remains serous in type, the *prognosis* is often *good.*

Treatment consists in the *removal of the cause* and the observance of directions given under retinitis in general.

ALBUMINURIC RETINITIS, OR RETINITIS OF BRIGHT'S DISEASE.

The retinitis which occurs in the course of *nephritis* usually presents *well-marked ophthalmoscopic signs* which are *almost pathognomonic.* There are, however, occasional cases of intracranial disease, especially tumor, which give rise to a neuro-retinitis resembling that of Bright's disease. It is usually *bilateral,* rarely unilateral.

Symptoms.—There is *disturbance of vision,* the degree depending upon the severity of the inflammation and especially upon the position of the exudations and hemorrhages. Minute changes in the macular region will cause considerable reduction in acuteness of vision, while extensive involvement of the rest of the fundus may affect the sight but very little.

Ophthalmoscopic Signs (Fig. 131, Plate V.) are those of retinitis in general: *swelling and haziness* of the *retina* and of the *papilla,* distention and *tortuosity* of the *retinal*

vessels, especially veins, and *hemorrhages* either in the form of flame-shaped or round spots, or larger extravasations. To these are added the *distinctive feature:* pure *white spots* found chiefly at the *macula and surrounding the disc*, less frequently elsewhere. *At the macula*, these spots are usually arranged in radiating lines which form a *star-shaped figure* with the fovea for a centre; or when less complete, the lines resemble the sticks of an open fan. *Near the disc*, and often more or less surrounding it, are *larger white spots.* The white spots found in both of these situations have a certain *brilliancy* due to fatty degeneration of the retinal elements and of the exudation.

Though this is the most frequent form of albuminuric retinitis, there are *other and less characteristic pictures* seen in nephritis; there may be simply retinal hemorrhages, simple retinitis, or hemorrhagic retinitis.

Albuminuric retinitis is sometimes described as occurring under *two forms:* 1, the *inflammatory*, when swelling, congestion, and hemorrhages are the predominating features; and 2, the *degenerative*, when the white spots and hemorrhages occur without swelling or congestion. The two forms are usually associated in varying proportions.

Etiology.—The affection is usually a complication of *chronic interstitial nephritis;* much less frequently of chronic *parenchymatous* nephritis; it may occur with *any form of nephritis* (scarlatina, pregnancy).

Pathology.—There is *disease of the walls of the retinal vessels* which leads to *inflammation* and *degeneration* of the retina.

Course and Prognosis.—Though the retinitis is *usually a late symptom* of Bright's disease, the disturbance of vision may be and not infrequently is the *first symptom* which calls attention to the nephritis. There is *no fixed relationship between the course of the nephritis, the amount of albumin, and the degree of retinitis.* There are cases in which the vision is but slightly affected even in the late

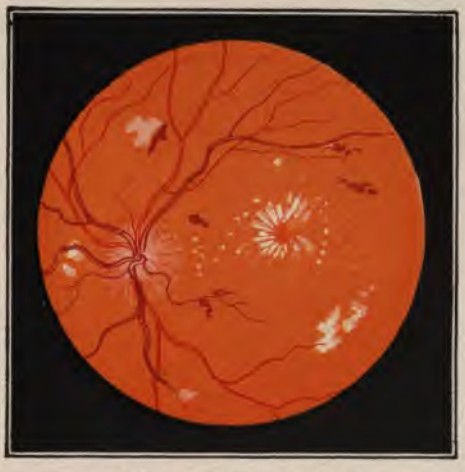


FIG. 131.—Albuminuric Retinitis.

FIG. 132.—Retinitis Pigmentosa.

stages, and others in which sight is seriously affected quite early. The condition is of *great prognostic importance* and indicates, with but few exceptions, a *fatal termination in from six months to two years.* The *exceptions* usually refer to cases occurring during pregnancy and scarlatina.

Treatment should be directed to the *nephritis;* no local treatment is of any value.

Gravidic Retinitis is the name given to retinitis *complicating the albuminuria of pregnancy.* Its signs and symptoms are the same as in the other forms of albuminuric retinitis, but they tend to *clear up after delivery.* It usually occurs during the *final months* of pregnancy, and the *prognosis* in regard to vision is often *good,* especially if labor be induced prematurely. When it occurs in the early months, the prognosis is less favorable, and the condition may warrant the *induction of abortion* in order to prevent further changes in the eyes.

Uræmic Blindness is the term used for *loss of sight during an attack of uræmia, without any changes in the retina.* It occurs in *pregnancy* and during the late stages of *scarlatina.* Similar attacks may also occur in patients who have *albuminuric retinitis.* It appears *suddenly,* affects *both eyes,* and is associated with *other symptoms of uræmia:* headache, vomiting, convulsions, and coma; the pupils are dilated but respond to light. After lasting a short time, or for a day or two, *normal vision usually returns. Treatment* is that of *uræmia.*

DIABETIC RETINITIS.

This form occurs as a late manifestation of glycosuria, but is *not common.* The *ophthalmoscopic appearances* resemble those of *albuminuric retinitis* in some cases, but in others they are characteristic: *small, bright, white spots* in and around the *macular region, grouped irregularly* and not in the form of a stellate figure; sometimes larger spots;

numerous punctate or larger *hemorrhages;* there is *no swelling* of the optic nerve and retina. The *prognosis* depends upon the systemic condition; the *treatment* is that of diabetes.

LEUKÆMIC RETINITIS.

This variety presents *marked swelling* of the retina and disc and numerous *hemorrhages.* The *blood-vessels* are greatly *dilated* and extremely tortuous and the *blood is very pale.* The entire *fundus* is *pale* and has a *yellowish hue.* There are white and yellow *spots of exudation,* and some of these present a pink border; they consist of white blood corpuscles surrounded by red blood cells.

SYPHILITIC RETINITIS.

A *common* form of retinitis found in both *hereditary and acquired syphilis.* In acquired syphilis, it occurs in the *secondary stage,* during the first or second year, and usually involves *both eyes.* It is generally *associated with chorioiditis* and often with *iritis.*

Ophthalmoscopic Signs.—*Indistinctness of the fundus* due to *swelling* of the retina and disc, and to fine, *dust-like opacities* of the posterior portion of the *vitreous;* these opacities *cause the disc to appear red and hazy;* scattered grayish or white *spots* often *fringed with pigment,* especially in the macular region; circumscribed *white exudations along the large blood-vessels,* forming white lines.

Subjective Symptoms consist of more or less *diminution* in the acuteness of *vision,* diminution in the light sense, *night blindness,* annoying *flashes* of light, *distortion* and changes in size of objects, central and ring *scotomata,* and later, *contraction of the field of vision.*

Course and Prognosis.—The *progress is slow and relapses are common.* The *prognosis* depends upon the stage during which treatment is begun; *if begun early* and carried

out vigorously, the prognosis is *good*, though *some impairment of vision* usually remains. *Neglected cases* are often followed by disseminated chorioiditis, pigmentary degeneration of the retina, and optic-nerve atrophy.

Treatment consists in the *thorough use of mercury* by inunctions and afterward *iodide of potassium*, *rest* of the eyes, *protection from light*, and *atropine*.

HEMORRHAGIC RETINITIS.

In this form of inflammation, *numerous and recurrent hemorrhages are added to the other signs of retinitis;* the extravasations of blood are abundant and both flame-shaped (superficial) and round and irregular (deep). This affection usually occurs in *elderly individuals* as a result of *diseases of the heart and blood-vessels*, and severe *disorders of the portal circulation*. It may be monocular or bilateral. *The prognosis is unfavorable*. New hemorrhages are apt to be added to the residua of the old ones; sometimes the affection terminates in *hemorrhagic glaucoma*. It is often a *forerunner of cerebral hemorrhage*. *Treatment* consists in *rest* for the eyes, *smoked glasses*, sometimes local abstraction of blood, and *ergot*. *Constitutional treatment* is of the greatest importance and enables the patient to profit from the warning of the danger of hemorrhages elsewhere which the ocular affection gives.

PURULENT RETINITIS.

This affection, also known as *metastatic retinitis*, results from the lodgment of *septic emboli* in the retinal arteries in the course of *puerperal* and other forms of *septicæmia and pyæmia*, and also from *infected wounds and foreign bodies*. In the first stage there are *small white spots and hemorrhages* around the disc and in the macular region; very soon, however, the uveal tract is invaded and the signs of

purulent chorioiditis (p. 161) appear. The inflammation ends in *panophthalmitis* or in degeneration of the eyeball without perforation (*pseudo-glioma*). Non-infected embolus gives rise to characteristic retinal changes (p. 235).

UNCOMMON FORMS OF RETINAL CHANGES.

A number of pathological conditions are found in the retina, which though uncommon, have received names describing the clinical picture in each case. Among these are *Retinitis Circinata* (presenting a crescentic or annular figure formed of white patches surrounding the macula); *Angeoid Streaks* (pigmented striæ resembling a system of obliterated blood-vessels); *Striated Retinitis* (yellowish or grayish streaks radiating from the disc to the periphery); *Punctate Retinitis* (numerous, small, white, or yellowish scattered spots); *Proliferating Retinitis* (dense vascularized masses of connective tissue which project from the retina into the vitreous).

Retinal Changes due to Excessive Light are seen after injurious *exposure of the eye*, (1) to the *sun*, especially in watching an eclipse with insufficient protection, (2) to the *electric light*, as in electric welding, and (3) to the *snow* (snow blindness). There are *pigment changes at the macula* and, corresponding to this, a central, positive *scotoma* which may become less marked, but does not disappear entirely. The *conjunctivitis* which results from exposure to excessive light is described on p. 82.

Symmetrical Changes at the Macula in Infancy (Amaurotic Family Idiocy).—This condition presents a clinical picture which somewhat *resembles* that of *embolism of the central artery:* a red spot at the macula surrounded by a grayish-white zone about twice the size of the disc; this is followed by *optic-nerve atrophy*. The disease occurs in *infants* who present general muscular and mental *weakness*. There is gradual *loss of sight*. *Death* results in a

year or two. It attacks several children of the same parents; all recorded cases have been of Jewish parentage.

Contusion of the Retina (Œdema of the Retina) is a *transitory clouding* of the retina resulting from *contusion* of the eyeball. It causes some diminution in acuteness of vision, which *disappears* with the retinal change *in a few days*

CIRCULATORY DISTURBANCES OF THE RETINA.

Hyperæmia of the Retina, when *slight,* is recognized by *increased redness of the disc* and by *slight striation* of its margins. Such a condition is often found in persons suffering from the effects of errors of refraction (*asthenopia*) and in those whose vocations expose the eye to *excessive light or heat. Marked* arterial hyperæmia is an *accompaniment of inflammation* of the retina and of surrounding ocular structures. *Venous hyperæmia* is seen as a result of pressure, in certain general diseases (especially heart disease), and in a most pronounced form in thrombosis of the central vein.

Anæmia of the Retina may be merely the ocular expression of a *general condition,* or it may be *local* The latter form may be *acute or chronic. Acute anæmia* is known as *ischæmia of the retina;* it may result from *occlusion* (embolism of central artery), *compression, or spasm* of the retinal arteries. There is extreme *narrowing* of the retinal arteries, *pallor* of the disc, and *blindness.* Such a condition is observed in cholera, and temporarily in migraine. *Quinine poisoning* furnishes an example of *ischæmia* in which some diminution in acuteness of vision and some contraction of the field of vision are permanent. The *chronic form of anæmia* is frequently seen after retinal disease causing *atrophy;* here the blood-vessels become narrower or even changed into slender, empty threads.

HEMORRHAGES INTO THE RETINA.

Retinal Hemorrhages often occur *without any signs of inflammation.* They *vary in size, shape, and position;* they are found most frequently in the neighborhood of the larger blood-vessels. When situated in the *nerve-fibre layer,* they have a *striate* or flame-shaped form; when *deep,* they are *rounded or irregular* in outline. Sometimes a large, round extravasation is seen in the region of the macula, between the retina and vitreous; this is known as a *subhyaloid hemorrhage.*

Retinal hemorrhages become *absorbed slowly.* The smaller ones may leave no traces. But more frequently *white spots,* sometimes *pigmented,* indicate their site. The *interference with vision depends* upon the *size* and particularly the *situation* of the hemorrhage; if at the macula vision is much diminished. A *scotoma* results if the retinal tissue has been injured. Subhyaloid hemorrhage causes no permanent change in vision after absorption, since the retina is not involved.

The *causes* of retinal hemorrhages are: (1) Injuries; (2) local disease of the vessels of the retina and chorioid; (3) diseased state of the blood-vessels, especially atheroma; this condition is commonly associated with heart and kidney disease, frequently found in old persons, and is often a warning of cerebral apoplexy; (4) disturbances in the circulation causing retinal embolism, thrombosis, hemorrhages in the new-born, and after operations; (5) valvular heart disease and cardiac hypertrophy; (6) changes in the composition of the blood and in the walls of the blood-vessels, seen in anæmia, leukæmia, purpura, scurvy, pyæmia and septicæmia, the malarial fevers, poisons, etc

Treatment of the etiological factor is indicated. Locally, there is none.

EMBOLISM OF THE CENTRAL ARTERY.

Symptoms.—Plugging of the central artery of the retina by a *non-infected embolus* causes *sudden blindness*, which is sometimes unrecognized by the patient, because it is usually *unilateral* and there is *no pain*. The *left eye* is the one generally affected.

There are *no external signs*, but the *ophthalmoscopic picture is very characteristic*. Within a few hours, the *fundus* becomes *pale* and œdematous, *grayish* or even milky; this is most pronounced *near the disc and macula* and fades out toward the periphery. In the situation of the *fovea* there is a bright *cherry-red spot* which stands out in marked contrast to the neighboring grayish-white retina; this is due to the red color of the chorioid seen through the very thin retina opposite this area. The *arteries are very thin* and can be followed only a short distance from the disc; beyond this point they may be *lost* entirely. The veins also contain less than the normal amount of blood. There may be small *hemorrhages*. Pressure upon the eyeball does not produce arterial pulsation, but gives rise to the appearance of broken columns of blood with clear spaces between them.

There is *sudden and complete blindness;* even perception of light is lost. Occasionally good central vision is preserved; this is due to the existence of a small macular branch given off from the central artery below its bifurcation, where the embolus usually lodges; but even in such exceptional cases, most of the field is lost.

The foregoing description applies to cases in which the main trunk of the central artery is occluded. The embolus may, however, lodge in *one of the branches of the central artery*. In such cases the interference with sight and the changes in the background will be limited to the *area supplied by the occluded branch*. Occasionally the embolus can be seen, but usually its presence is shown by a swelling in the artery, beyond which the vessel is thin or obliterated.

After embolism of the trunk of the central artery has lasted a few days, *degeneration of the retina* occurs, and after a few weeks *atrophy* sets in. The œdema subsides, the disc atrophies, and the blood-vessels become shrunken or are represented by white lines.

Etiology.—Plugging of the central artery is most frequently due to *valvular heart disease*, less often to atheroma, aneurism, Bright's disease, and pregnancy. A *thrombus* of the central artery may give rise to the *same signs and symptoms* as embolism, and a differential diagnosis is difficult or impossible.

Treatment *is rarely effective.* If the case is seen early, *paracentesis* of the cornea, *massage* of the eyeball, and inhalations of *amyl nitrite* have been employed for the purpose of driving the plug along into one of the smaller branches, where it will give rise to less serious results; in a few cases, such treatment has been beneficial.

Thrombosis of the Central Vein may occur in *old persons* with *atheroma* and *cardiac disease;* it also follows *cellulitis of the orbit.* It is one of the causes of hemorrhagic retinitis. It may be *complete or partial.* There is *diminution of vision*, either corresponding to the entire field, or if only a branch is affected, to the part of the retina supplied by it. The *veins* are *greatly engorged* and tortuous, the *arteries* very *small*, there are *numerous large hemorrhages*, and *indistinctness* of the margins of the *disc.* The condition usually *ends in atrophy* of the retina and disc. There is *no treatment.*

PIGMENTARY DEGENERATION OF THE RETINA, OR RETINITIS PIGMENTOSA.

A *chronic* form of *retinitis*, which has a constant tendency to become worse, and which consists of *atrophy of the retina, with migration of pigment* from the pigment epithelium into the inner layers.

Symptoms.—*Night blindness* (hemeralopia), *concentric contraction of the field* of vision, *progressive diminution in sight*, terminating in advanced years in *complete blindness*.

In early life there is but slight reduction in the extent of the field *with good illumintion*, and *central vision is often perfect*. But *with feeble illumination*, the peripheral parts of the retina do not react, and on this account the patient cannot find his way about at night, because the *field is small*. With *increasing years*, the *field* becomes *contracted* even with good illumination. Finally, in *advanced life*, central vision becomes poor, and gradually complete *blindness* follows.

Ophthalmoscopic Examination (Fig. 132, Plate V.) shows *black spots in the periphery of the fundus*. These have the *shape of branching cells*, like bone corpuscles with connecting processes, and are found especially along the blood-vessels. In the course of years new spots form, and in this way the *pigment circle* gradually approaches the disc. Migration of coloring-matter from the pigment layer of the retina allows the *chorioidal vessels* to become *plainly visible*. *The disc and retina are atrophied.* The *disc* has a *yellowish*, *waxy* appearance. The retinal *arteries* are very *small* and in the periphery are represented by mere threads.

There are cases of retinitis pigmentosa in which all the symptoms of this disease are present, and the ophthalmoscope shows all changes *except the presence of pigment*, and others in which the pigment is distributed in an *atypical* manner. Syphilitic chorio-retinitis may give a picture similar to that of retinitis pigmentosa, but may be differentiated by the patches of chorioidal atrophy.

Occurrence.—The disease affects *both eyes*. It is either *congenital* or develops in *childhood*. It is *hereditary* and is often found in the offspring of *consanguineous marriages*; not infrequently *other congenital defects*, such as deafness and defective intelligence, are present. It may be com-

plicated with posterior polar cataract and other ocular anomalies.

Treatment is of no avail.

DETACHMENT OF THE RETINA.

Retinal detachment is a *separation of the retina from the chorioid.* The name usually refers to a separation by *serum*, but detachment may also occur as a result of *subretinal hemorrhage, exudation, or tumor.*

Symptoms.—There is more or less complete *loss of vision* in that *part of the field* which is opposite to the detachment, and the appearance of a dark *cloud before the eye;* early symptoms are *metamorphopsia* and flashes of light (*photopsia*). *Central vision is preserved* as long as the *macula is not included.*

Ophthalmoscopic Signs depend upon the degree and extent of detachment. *When the detachment is flat,* the retina appears but slightly changed; it is somewhat *cloudy* and its *vessels are dark and tortuous;* the variation in *level* of the affected portion can be recognized by the *difference in the refraction* of a blood-vessel on the separated part. *When the detachment is steep,* as is *generally* the case, it is usually found *near the periphery.* It is *at first limited* in extent; it may commence at any part of the retina, but as a result of sinking of the subretinal fluid it is usually found *below.* It tends to enlarge and become total, then involving the entire retina. It presents a collection of *grayish,* bluish-gray, or *greenish folds* (Fig. 98, Plate IV.) with white tops *projecting* a variable distance into the vitreous and *shaking* with movements of the eye. The *blood-vessels pass over* and follow these folds and are therefore *very tortuous,* and *hidden* at places; they appear *prominent* and of a *dark red,* almost black color. Sometimes a rupture can be seen in the separated retina. In the later stages, opacities of the vitreous and cataract are often added. The *rest of the fun-*

dus presents a *normal* picture. *Externally* the eye appears *normal*, but *tension* is usually *lowered* and the *anterior chamber deepened.*

Etiology.—Serous detachments may be due to *injury or disease.* Traumatic detachment is usually the result of *blows;* it may follow accidental or operative *wounds*, especially when there has been *loss of vitreous.* When due to *disease*, it is generally found in *myopia* of high degree, and after disease of the vitreous, iridocyclitis, and irido-chorioiditis. In such cases the condition probably results from the *shrinking* of the vitreous, which thus pulls the retina from its attachment. Other forms of detachment are much less frequent and are due to *subretinal hemorrhage, exudation, or tumor.*

Diagnosis *is readily made*, but it is sometimes *difficult to decide* whether the detachment is *serous*, or due to a *tumor* of the chorioid (p. 168).

Prognosis *is unfavorable.* The detachment tends to *enlarge* and to become total. Even after improvement, *relapses* are the rule, and *complete blindness* is the usual end.

Treatment is sometimes followed by *temporary improvement*, but is rarely productive of lasting benefit. In recent cases, the best treatment is *absolute rest in bed* with a *firm bandage* applied to both eyes, kept up for six to ten weeks. *Potassic iodide*, and daily subcutaneous *injections of pilocarpine* in sufficient dose to produce sweating and salivation (gr. $\frac{1}{12}$) are often tried.

Puncture of the sclera (posterior sclerotomy, p. 189) is frequently resorted to and may be successful, but this is almost always only a *temporary gain.*

CHAPTER XIX.

DISEASES OF THE OPTIC NERVE.

Anatomy.—The optic nerve may be divided into (1) an *intraocular portion*, the *retina;* (2) an *orbital portion* extending from the eyeball to the optic foramen; and (3) an *intracranial portion* situated between the optic foramen and the chiasm.

The nerve pierces the sclera and chorioid a little to the inner side of the posterior pole of the eyeball. At this point the outer layers of the sclera become continuous with the sheaths of the nerve, while the inner layers together with the modified chorioid stretch across the foramen, presenting numerous openings for the passage of the separate bundles of the optic nerve; this sieve-like arrangement is known as the *lamina cribrosa*. Here the *nerve fibres lose their medullary layer* and become transparent. Spreading apart before reaching the level of the retina, they leave a funnel-shaped depression at the middle of the disc (Fig. 24), the *physiological excavation*.

The *lamina cribrosa* represents the *weakest portion* of the layers of the eyeball, and in increased tension is the first to recede. It surrounds the bundles of the optic nerve with fibrous rings of connective tissue, which serve as *constricting bands* when swelling occurs.

The *orbital portion* of the optic nerve presents a sigmoid curve permitting free movement of the eyeball. The nerve consists of bundles of *nerve fibres* separated by *connective-tissue septa;* between these there are *lymph spaces*. The optic nerve is surrounded by *three sheaths* originating from

the three envelopes of the brain, and known as the pial, arachnoid, and dural sheaths; between the pial and the dural sheaths is a space, the *intervaginal space*, divided into two parts by the arachnoid sheath. The two spaces thus formed are *lymph spaces;* they are lined by endothelium, and *communicate with* the corresponding *cerebral spaces.* Anteriorly, the intervaginal space ends in a blind extremity and the sheaths unite with the sclera.

A short distance from the eyeball, the *central artery* (a branch of the ophthalmic) enters, and the *central vein* emerges; the latter empties into the superior ophthalmic vein or directly into the cavernous sinus.

The *intracranial portion* of the optic nerve is the short, flattened part which extends between the optic foramen and the chiasm. The *optic foramen* forms an *unyielding ring* which serves to *compress* the nerve in inflammation and injury.

Affections of the Optic Nerve comprise (1) *hyperæmia*, (2) *inflammation*, (3) *atrophy*, and (4) *tumors* (very rare).

HYPERÆMIA OR CONGESTION OF THE OPTIC DISC.

The normal disc varies greatly in color; hence it is often difficult to decide whether the papilla is congested or not. When congestion exists it shows itself in increased *redness* due to capillary injection, slight *blurring and striation of the margins of the disc* often limited to a portion of the circumference, and some *fulness of the veins.*

Such a picture is frequently presented in *eye strain* from hyperopia and astigmatism, *excessive use* of the eyes, or after work with *insufficient or excessive light.* It is also found with *inflammations* of the deeper portions of the eyeball. It may be the *incipient* stage of optic *neuritis.*

INFLAMMATION OF THE OPTIC NERVE.

This is known as *Optic Neuritis* and is divided into:

1. *Papillitis, or Intraocular Optic Neuritis,* in which the *head* of the optic nerve is the part affected, and in which there are *marked visible changes in the disc.*

2. *Retrobulbar Neuritis* affecting the *nerve fibres behind the eyeball,* and in which the *changes of the disc are slight,* and the existence of inflammation is often inferred from subjective symptoms.

PAPILLITIS, INTRAOCULAR OPTIC NEURITIS, OR CHOKED DISC.

Symptoms.—There is more or less *disturbance of vision;* it is usually *considerable,* but it is *not always proportionate to the severity of the inflammation* as revealed by the ophthalmoscope; there may be complete blindness. The *field of vision* is usually *contracted* peripherally, especially for colors. There may be *hemiopia* or *scotomata.* There is *no pain,* and there are *no external signs.*

Ophthalmoscopic Signs.—The *papilla* appears *swollen* and projecting (Fig. 133), *enlarged,* of *whitish or grayish color, striated,* and often presenting *white spots and hemorrhages.* Its situation is recognized only by the convergence of the retinal blood-vessels, its *margins* having become *indistinguishable* and extending gradually into the surrounding retina. The *retinal vessels* are altered and are *interrupted* in places; the arteries are either thin or of normal calibre, the *veins* are greatly *distended* and exceedingly *tortuous.* The *surrounding retina* is usually œdematous, *congested,* and presents *white patches and hemorrhages.* When a large portion of the surrounding retina is involved the affection constitutes *neuro-retinitis* (Fig. 134, Plate VI.).

Clinical Forms.—Clinically we may distinguish between *two types* of papillitis: 1. *Choked Disc,* in which there is

marked swelling limited pretty sharply to the disc, with *extreme dilatation and tortuosity of the veins; œdema and engorgement* are the predominating features. 2. *Descending Neuritis*, in which there are less swelling and projection of the disc, less venous fulness and tortuosity, but *more exudation* and considerable *extension* of the latter *into the surrounding retina;* the picture in these cases points more to *inflammation*. *No sharp line* can, however, be drawn between these two forms, either from the standpoint of pathology or of etiology, and *transition forms* occur frequently.

FIG. 133.—Papillitis (Choked Disc). The upper portion represents the ophthalmoscopic appearances; the lower half, a longitudinal section.

Course. — Though occasionally acute, the course is usually a *chronic* one, extending over a *number of months*. It is possible for the changes to subside and the disc to regain its normal appearance with the preservation of good sight (especially in syphilitic cases). But, as a rule, papillitis is *followed by Post-neuritic Atrophy*. The *disc* becomes *white or grayish-white*, its *margins* are sharply defined but *irregular*, and surrounded by changes in the chorioid, while the *exudation* becomes changed into *connective tissue* which *covers the lamina cribrosa* and fills up the physiological cup; the *arteries are contracted* and frequently *bordered by white lines*, but the *veins* remain *dilated and tortuous*.

Prognosis is always *serious*. The *degree of atrophy* depends upon the intensity of the preceding neuritis, and determines whether vision finally becomes useful, much impaired, or totally lost.

Etiology.—Papillitis is almost always *bilateral*, but one eye may be affected before the other. The *causes* are: (1) diseases of the brain and its envelopes; (2) syphilis; (3) general diseases; (4) anæmia, either simple, or the acute form due to great loss of blood; (5) diseases of menstruation, pregnancy, and lactation; (6) lead poisoning; (7) heredity; (8) idiopathic cases (when no cause can be found); and (9) orbital and periorbital affections.

Brain Tumor is the *most frequent cause;* papillitis occurs in 90 per cent. of such cases and then most commonly assumes the *choked-disc type*. Sometimes the neuritis is the first symptom of brain tumor. The occurrence or degree of papillitis does not depend upon the size or the situation of the tumor. It frequently exists with cerebellar tumors. The neuritis of brain tumor occasionally gives a picture resembling that of albuminuric retinitis with its star-shaped figure at the macula.

Next in frequency comes *meningitis*, especially basilar and tuberculous. In such cases the papillitis is apt to be of the descending neuritis type. Then come *abscess and hydrocephalus*.

Syphilis is a frequent cause, and acts either by direct implication or through the development of specific affection in the cranial or orbital cavities.

Acute febrile affections (measles, scarlatina, diphtheria, typhoid, grippe) are *occasional* causes.

General affections such as rheumatism, nephritis, and arterial disease are sometimes responsible; also exposure to *cold*.

Orbital and periorbital affections include inflammations of the orbit, tumors of the orbit and optic nerve, and diseases of the neighboring cavities (sphenoid, ethmoid, frontal, and maxillary). These constitute the examples of *unilateral* cases.

Pathology.—The process consists of an *inflammatory swelling, exudation* of leucocytes, *venous engorgement, hem-*

orrhages, and *distention of the intervaginal space*. The exact mechanism is still unsettled. Numerous *hypotheses* have been advanced; the most prominent are: (1) that it is due to increased *intracranial pressure* forcing cerebro-spinal fluid into the intervaginal space of the optic nerve, causing stasis in the region of the lamina cribrosa, compression of the vessels resulting in venous engorgement and œdema (choked disc); (2) *transmission of inflammation from the brain* along the optic nerve to the papilla; (3) inflammation excited by *irritating substances* which pass from the cranial cavity to the optic disc.

Treatment should be directed against the *cause* of the inflammation. *Trephining* the skull has been followed by improvement. In *syphilis*, a vigorous course of *mercury* followed by *potassic iodide*. Even in non-specific cases mercury and iodide of potassium are often prescribed. *Locally*, *rest* of the eyes, *shading* from light, and sometimes abstraction of blood from the mastoid region.

RETROBULBAR NEURITIS.

This affection involves the *orbital portion* of the optic nerve. Hence, until atrophy makes its appearance, there are *few* or no *changes in the disc*, and the diagnosis is made from the *disturbance of vision*. In most cases there is merely an implication of the *papillo-macular* fibres of the optic nerve, and consequently the alteration in the field of vision takes the form of a *central scotoma*, often relative. There are *two forms*, *acute and chronic*.

ACUTE RETROBULBAR NEURITIS.

This rather *uncommon* affection is generally *unilateral*, occasionally bilateral.

Symptoms.—*Neuralgia* or *headache* on the same side, *pain* in and about the *orbit* aggravated by movements of

the eye, and *tenderness* on pressing the eye backward into the orbit. With these symptoms there is *rapid impairment of sight*, progressing in the course of a week to *partial or complete blindness*. *Externally* the eye appears *normal*.

Ophthalmoscopic Signs.—*At first* there are *no changes; later* there may be slight *haziness of the disc*, with *distention* and sometimes *diminished calibre* of the *retinal vessels*.

Course.—The disease runs an *acute* course, and after a month or two, the *sight* usually becomes *normal;* or the cure is partial, and a *central scotoma* remains; occasionally it terminates in permanent and total blindness.

Etiology.—Exposure to *cold*, *rheumatism*, *syphilis*, *acute infectious diseases*, alcohol and other *poisons*, and *extension* of neighboring inflammation.

Treatment.—Removal or treatment of the *cause*. Diaphoresis by the use of *pilocarpine; sodium salicylate*. *Potassic iodide*, *mercury*, and *strychnine* are also employed.

CHRONIC RETROBULBAR NEURITIS, TOXIC AMBLYOPIA, TOBACCO OR ALCOHOLIC AMBLYOPIA.

A *chronic* affection of the *orbital portion of the optic nerve*, of *frequent* occurrence, usually attacking *both eyes*, and due in the great majority of cases to excessive indulgence in *tobacco*, *alcohol*, or *both* combined.

Symptoms.—There is gradual *diminution* in acuteness of *sight; foggy vision;* the patient sees better in the evening and the visual disturbance is *more marked in bright light*. The field of vision presents the normal peripheral boundary, but there is a *central color scotoma* for red and green, corresponding to the distribution of the papillomacular fibres of the optic nerve. This *color defect* is usually *small*, but it may be more extensive and correspond to the limits of the color fields.

The *scotoma* is detected by having the patient fix the examiner's finger at about fifteen inches, the other eye being

closed, and moving *small pieces of red or green worsted or cardboard* (about 5 mm. in diameter) from the periphery toward the point of fixation; when the test object arrives at the seat of the scotoma it will appear *dull or colorless.* Sometimes the scotoma becomes *absolute* (no perception of light over this area).

Ophthalmoscopic Signs.—*Sometimes* there are *no changes* in the papilla, or merely a *slight haze* with increased *redness.* At a *later period,* there is very often a *pallor of the temporal side of the disc.*

Course.—The course of the disease is *slow. If poisoning continues, vision* becomes more *impaired* and may be reduced very much. *If the patient stops* the use of the toxic material, there is usually *gradual improvement* and sight is often restored to the normal, with complete *disappearance of the scotoma.* But in *severe cases,* there may be some *permanent reduction* in the acuteness of *vision,* and the relative *scotoma may continue* indefinitely.

Etiology.—The condition results most frequently from *over-indulgence in tobacco* whether in smoking or chewing, occasionally after snuff-taking. The *stronger tobaccos* used in cigars and pipes are the forms which are most frequently responsible. Certain individuals are more *susceptible* than others. *Impairment of the general health predisposes,* as does also the practice of smoking when the stomach is empty. It occurs almost exclusively in *middle-aged or elderly men. Alcoholic stimulants* also constitute a very frequent cause; in most cases both alcohol and tobacco act together. *Other poisons* which in toxic doses cause a condition resembling tobacco amblyopia are iodoform, lead, arsenic, the poison of diabetes, wood-alcohol, bisulphide of carbon, and nitrobenzol.

Pathology.—The *process* consists of an *interstitial neuritis of the papillo-macular* (axial) *fibres* of the optic nerve.

Treatment consists in *abstinence from tobacco and alcohol;* if some stimulant is required, it must be restricted to

a small amount with the principal meals. The *general health* should be *improved*. *Strychnine* is given by mouth or hypodermically in increasing doses, up to the limit of tolerance. *Iodide of potassium* is sometimes prescribed, and used in alternating periods with the strychnine.

ATROPHY OF THE OPTIC NERVE.

This affection occurs either as a *primary* disease (*simple, primary, non-inflammatory, or progressive atrophy*) or *secondary* to some other affection of the nerve or retina (*post-neuritic, secondary, or inflammatory atrophy*).

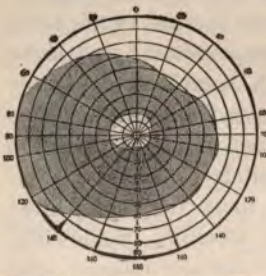


FIG. 136. — Marked Concentric Contraction of the Field of Vision in Optic-Nerve Atrophy.

Symptoms.—There are *reduction* in the acuteness of *vision*, *concentric or irregular contraction of the field* (Fig. 136), first for colors and then for form, diminution in the light sense, sometimes *scotomata*, and *color blindness* (first for green, then for red, then for blue). These *symptoms* tend to *progress* and end in complete *blindness*.

Ophthalmoscopic Signs differ somewhat in the simple and post-neuritic forms:

In *Simple Atrophy* (Fig. 135, Plate VI.), the *disc* is *white, grayish, or bluish-white*, its *edges* are *sharply defined and regular*, its *size* is somewhat *diminished*, and it presents a *saucer-shaped excavation* (Fig. 95); the *lamina cribrosa* is often *seen very plainly*. The *minute vessels* of the disc have *disappeared*. The retinal vessels may appear normal, but the *arteries* are usually *diminished in calibre*.

In *Post-neuritic Atrophy*, the *disc* is *covered by connective tissue* resulting from the previous neuritis. It has a dense *white or grayish* color, with more or less *irregularity* and

FIG. 134.—Neuro-Retinitis.

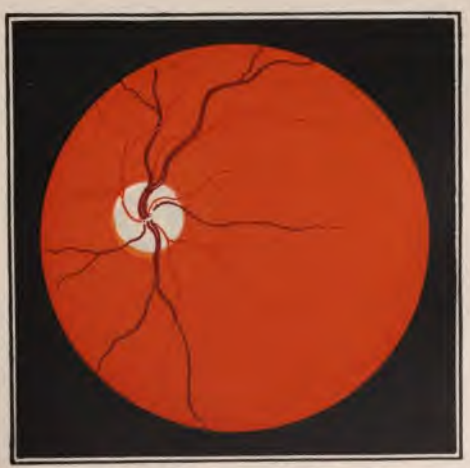


FIG. 135.—Simple Atrophy of the Optic Nerve.

obscuration of the *margins*, its *minute vessels* have *disappeared*, and the *lamina cribrosa* is *hidden* by the organized exudation. The retinal *arteries* are *narrow*, enclosed in *white lines*, and the *veins* are *enlarged and tortuous*.

In the *secondary atrophy following retinitis pigmentosa* the *disc* has a *dirty, grayish-red or yellow, waxy* look (Fig. 132, Plate V.), the *vessels* are *exceedingly narrow* and many disappear entirely.

After a time, the differences in the appearances of simple and post-neuritic atrophy become much less marked.

It should be borne in mind that the *disc varies in color in health* and may appear atrophied as the result of *congenital or senile peculiarities*, although vision is normal and the field perfect; hence the diagnosis cannot be made from the ophthalmoscopic signs alone, especially when these signs are not pronounced.

Etiology.—*Simple atrophy* is frequently due to *spinal diseases*, especially *locomotor ataxia;* it develops in one-third of the cases of this affection and is an early symptom. It is common also in *affections of the brain:* disseminated sclerosis, general paralysis of the insane, and tumors. It is also due to *syphilis*, malaria, diabetes, acromegaly, impaired nutrition, and certain poisons. *Occasionally* it is *hereditary*, and in some cases *no cause* can be found. It occurs chiefly in *middle life*.

Secondary atrophy follows papillitis, retrobulbar neuritis, retinitis, pigmentary degeneration of the retina, embolism of the central artery, and *glaucoma*. It may follow penetrating wounds of the optic nerve or injury to the nerve due to fracture of the orbital canal, following a blow or other violence; in such cases the atrophy does not show itself for a number of weeks, though more or less interference with vision results immediately.

Pathology.—The process consists of *increase in the interstitial connective tissue with atrophy of the nerve fibres*.

Prognosis is usually *unfavorable*. *Simple atrophy* gen-

erally progresses to *absolute blindness.* In *secondary atrophy* the prognosis is *better,* and depends upon how much sight has been destroyed by the antecedent inflammation.

Treatment consists in attempting to control the *cause* of the atrophy. For the atrophy itself very little can be done. *Potassium iodide, strychnine, mercury, nitroglycerin,* and *galvanism* are the remedies most frequently employed.

CHAPTER XX.

AMBLYOPIA AND FUNCTIONAL DISEASES OF THE RETINA.

Amblyopia is a *reduction in the acuteness of vision* which cannot be relieved by glasses and which is not dependent upon any visible changes in the eye. The term is sometimes used in a less restricted sense to designate poor sight, even when some changes are found in the eye, as, for instance, toxic amblyopia in which temporal pallor of the disc exists.

Amaurosis is the name applied to *absolute blindness* when unaccompanied by discoverable ocular changes; the use of this term has, however, been extended so as to include all cases of absolute blindness, including those which show ophthalmoscopic or external changes.

CONGENITAL AMBLYOPIA.

Congenitally defective vision, usually of *one eye* but sometimes affecting both. It is frequently *associated* with *high degrees of hyperopia, myopia, and astigmatism.* In such cases, the errors of refraction have prevented perfect images from being focussed on the retina, and this lack of training has caused amblyopia. The most careful correction of the error of refraction fails to produce normal vision; in young patients, however, the sight can frequently be improved or brought up to the normal after *suitable glasses* have been worn for a time.

Any interference with vision dating from early life,

which prevents perfect focussing upon the retina, causes *amblyopia from non-use* (*amblyopia ex anopsia*); hence the advisability of operating upon congenital and infantile cataracts early. An obstacle to vision beginning in adult life does not usually interfere with the functional activity of the retina.

Unilateral amblyopia frequently results in *squint* of the affected eye. It is also true that amblyopia develops in an eye which has squinted from early life on account of its exclusion from the visual act, the patient finding it convenient to suppress the retinal image in this eye (p. 357).

Exercise of such an eye during youth, by forcing it to work while the sound eye is excluded, will frequently *improve its visual power.*

Congenital amblyopia usually remains *stationary* except when, in young subjects, it can be improved by exercise of the affected eye. When the defect is bilateral, *nystagmus* is apt to develop.

HYSTERICAL AMBLYOPIA.

This condition usually occurs in *young girls and women*, occasionally in young persons of the male sex. It is almost always *unilateral.*

Symptoms.—The most constant symptom is a *diminution* in the acuteness of *vision* which frequently amounts to complete *blindness.* The *field* of vision is *contracted concentrically*, both for white and colors; since the *retina becomes exhausted rapidly*, this limitation may become more marked with each succeeding test during the same examination. The *color fields do not have the same relative areas as with the normal eye;* they may be larger than that for white; their order is often *reversed—i.e.*, green the largest, red next, and blue the smallest. There may be *scotoma* or *hemiopia. A great variety* of other ocular symptoms may be present, such as photophobia, flashes of light, blepharo-

spasm, corneal anæsthesia, monocular diplopia, ptosis, and changes in the size and shape of images. *The pupillary reflexes and ophthalmoscopic appearances are normal.*

With these ocular manifestations there are usually *other hysterical symptoms*, especially *hemianæsthesia* of the affected side. It is sometimes difficult to distinguish between this affection and *malingering*. It sometimes follows injuries (*traumatic hysteria*) even when these do not involve the eye.

Prognosis is *good*, although the affection may *last many months* or even a number of years.

Treatment is directed to the *hysterical condition*. *Locally, electricity, massage*, and hypodermic injection of *strychnine* are productive of good results, probably through *psychic influences*.

SIMULATED AMBLYOPIA. MALINGERING.

Patients sometimes *pretend to be blind in one eye* in order to escape military duty or to recover damages for alleged injury; occasionally bilateral blindness is simulated.

The *detection* of pretended monocular blindness is usually *easy*. One of the following tests may be employed:

Tests.—1. Place a *lighted candle* fifteen or twenty feet in front of the patient and put a prism of 6°, base upward or downward, before the sound eye; if the patient sees double it is an indication that the vision is good in both eyes.

2. With the *lighted candle* in the same position, cover up the supposed blind eye. Then produce *monocular diplopia* by moving a 6° prism, base upward or downward, until the apex corresponds to the centre of the pupil. Next uncover the blind eye and at the same time move the prism until it covers the entire pupil. If now there is still double vision (binocular diplopia) it is evident that both eyes see.

3. Place a *strong convex lens* (12 D.) before the good eye and a weak concave lens (0.25 D.) in front of the supposed blind eye, and direct the patient to read the *distant test types;* if he succeeds, it is proof of malingering, since it is impossible for him to see with the sound eye when covered by the strong lens.

It is *rare* for a patient to simulate blindness in *both eyes*, and more *difficult to detect* him in such cases. A diminution in acuteness of vision of both eyes is more frequently feigned than binocular blindness. In such cases, malingering is suspected when there is an *absence of agreement* in the results of the *functional and objective examination* of the eyes, *contradictory statements* regarding the different steps in the functional examination, or contraction of the pupils to light. In rare instances, the pupils react on exposure to light in cases of absolute blindness, the lesion being situated in the visual centre or in the connection between this centre and the corpora quadrigemina (*3*, Fig. 137). In feigned binocular blindness a *close watch* must be kept on the patient when he thinks he is free from observation, and the following test may be employed: Place a lighted candle in front of the patient; hold a 6° prism base outward before one eye; if both eyes see, the one covered by the prism will move inward in order to avoid diplopia; on removing the prism it will move outward, the other eye remaining fixed.

COLOR BLINDNESS.

Congenital Amblyopia for Colors (*Daltonism*) occurs in from three to four per cent. of *males* and in considerably less than one per cent. of *females*. It generally affects *both eyes*, is often *hereditary*, and the functions of the *eyes* are *otherwise normal*. The *cause and pathology are unknown* and the disease is *incurable*. The condition is usually a *partial achromatopsia*—a loss of perception of *one or two* of the

fundamental *colors* (red, green, and blue). The absence of all appreciation of colors, *complete achromatopsia*, is very rare as a congenital defect, though it is not uncommon in acquired color blindness occurring in optic-nerve atrophy.

Two theories have been adopted *to explain color perception* and its derangements: (1) the Young-Helmholtz theory, (2) the Hering theory.

The Young-Helmholtz Theory assumes that there are three primary color perceptions in the retina corresponding to the three fundamental colors—red, green, and violet; and that all other colors arise from combinations of these. With a defect of one of these primary perceptions, a color will be seen as if composed of the remaining two only. According to the color which is deficient, the patient is said to be *red-blind*, *green-blind*, or *violet-blind*. The more commonly recognized forms are *red blindness*, *green blindness*, and *red-green blindness*.

The Hering Theory asserts that there are three pairs of visual substances in the retina—white-black, red-green, and blue-yellow. According to this theory, color blindness is caused by the absence of one or two of these visual substances.

Tests for Color Vision are useful in the examination of employees in certain occupations in which perfect color perception is essential. This is of especial importance in the *railway and steamship service*, in which the most commonly used *signals are red and green*, the colors in which most color-blind persons are defective.

The most common and convenient method of examination is *Holmgren's test with a large assortment of colored worsteds*. This collection consists of (1) certain colors called "*test colors*" (a *pale green*, a *light pink*, and a *bright red*), (2) lighter tints and darker shades of these colors ("*match colors*"), and (3) "*confusion colors*," hues which experience has shown that the color-blind individual will select as matching the test colors, but which appear en-

tirely different to the normal eye. To the color-blind patient is given one of the test skeins and he is told to pick out any worsteds that *match* it; he will not only select similar colors but will add a number of *confusion colors*—yellow, brown, gray, drab, fawn, mauve, pale blue, etc.; in addition he will show by a certain *hesitancy* in choice that his color sense is defective.

Other tests, including the *spectroscope*, are employed for the same purpose.

Acquired Color Blindness is often found as a symptom of *diseases of the retina and optic nerve.* It is generally present in *optic-nerve atrophy* when vision is markedly impaired.

Colored Vision is occasionally complained of by patients with or without changes in the retina. The most frequent form is *red vision* (*Erythropsia*) after cataract extraction. Rarely green, blue, or white vision is met with.

AMBLYOPIA AND AMAUROSIS FROM VARIOUS CAUSES.

Besides the forms of amblyopia already described, there are others, of less frequent occurrence, due to *uræmia*, *reflex* irritation, *malaria*, and *quinine.* A considerable number of *drugs* are occasionally responsible for more or less complete amblyopia.

Uræmic Amblyopia has been described on p. 229.

Reflex Amblyopia, due to reflex irritation, is rare and of rather doubtful occurrence, except in the case of the teeth, irritation from which has been found responsible for amblyopia in occasional instances.

Malarial Amblyopia has been observed in malarial diseases. It affects one or both eyes, lasts some hours or days, and usually disappears completely as a result of the use of antiperiodics.

Quinine Amblyopia or Amaurosis occurs after large quantities of quinine have been taken, occasionally with moder-

ate doses in susceptible individuals. Besides other symptoms of cinchonism there are more or less complete *blindness*, often noticed suddenly, *contracted fields*, dilated pupils, and marked *pallor of the disc*, with *extreme contraction of the retinal vessels*. The condition is due to *spasm* of the retinal *vessels* causing anæmia of the fundus. After a time, *central vision is restored* completely or partially, and the *field widens*, but rarely regains its full extent. *Treatment* consists in *discontinuing the drug*, the use of bromides, strychnine, digitalis, nitroglycerin, and inhalations of nitrite of amyl.

Night Blindness, *Hemeralopia* (sometimes called nyctalopia) is a condition in which the *sight is good by day* or with good illumination, but more or less *deficient at night* or with reduced illumination. It is a symptom of certain forms of *retinitis*, especially *retinitis pigmentosa*, but it also occurs without ophthalmoscopic changes. The latter form of diminished light sense is caused by anæsthesia of the retina; it usually coexists with xerosis of the conjunctiva and is dependent upon the same cause—diminished ocular nutrition due to a debilitated state of the system, such as exists in starvation, profound anæmia, scurvy, and the like. The affection usually disappears with improvement of the general health by good and sufficient food, tonics (cod-liver oil, iron), and the use of dark glasses.

Day Blindness, *Nyctalopia* (sometimes called hemeralopia) is the name given to a condition in which the *sight is better at dusk* or in *feeble illumination* than in bright light. This symptom is found in *tobacco amblyopia* and with *central scotoma* in general. In cases in which there are central opacities of the lens or cornea, the patient sees better in reduced illumination because the dilated pupil permits vision through the peripheral clear portion of the cornea and lens.

HEMIANOPSIA, HEMIANOPIA, OR HEMIOPIA.

Connection between the Retinæ, the Fibres of the Optic Nerves and Tracts, and the Cerebral Cortex (Figs. 89 and 137).—Familiarity with the course of the optic-

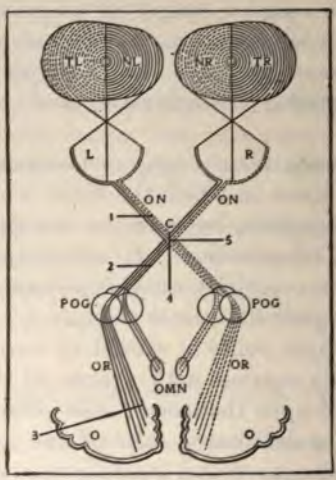


FIG. 137.—Schematic Representation of Visual Paths. *L*, Left eye; *R*, right eye; *TL*, temporal field of left eye; *NL*, nasal field of left eye; *NR*, nasal field of right eye; *TR*, temporal field of right eye; *ON*, optic nerve; *C*, chiasm; *POG*, primary optic ganglia; *OMN*, oculomotor nuclei; *O*, occipital lobe; *OR*, optic radiations. Division of fibres at 1 causes complete blindness of the left eye and loss of direct pupillary reaction; at 2, right homonymous hemiopia with loss of reaction of the pupil when the left halves of the retinæ are illuminated; at 3, right homonymous hemiopia with preservation of the reaction of the pupil when the left (and right) halves of the retinæ are illuminated; at 4, bitemporal hemiopia; at 5, left nasal hemiopia.

nerve fibres from the eye to the cortex is of great practical value in the localization of various lesions causing defects in the field of vision.

The *optic nerves* terminate at the *chiasm*, which lies in the optic groove on the body of the sphenoid bone, where they *semi-decussate;* from the posterior border of the chiasm they are continued backward as the optic tracts.

The *optic tracts* pass outward and backward, winding around the crura cerebri to the *primary optic ganglia*—the external geniculate bodies, the anterior corpora quadrigemina, and the pulvinar of the optic thalami (*POG*, Figs. 89 and 137). Here the fibres divide into two portions: (1) a smaller part passing to the *nuclei of the oculomotorius* and presiding over the reflex action of the *pupils* and the movement of the *ocular muscles*, and (2) a larger bundle, composed of visual fibres, which transfers its impulses (Fig. 89) to other fibres which carry the visual impressions to the *cortex;* the latter fibres pass through the posterior portion of the internal capsule, then form the *optic radiations* or fibres of Gratiolet, and end in the cortical ganglion cells of the *mesial surface of the cuneus* and the parts surrounding the *calcarine fissure;* this portion of the occipital lobe is known as the *visual area of the cerebral cortex* (*O*, Fig. 137).

In the ganglion cells of the visual area, an excitation in the optic nerve fibres is changed into a *sensory perception* (*sight*) or *into permanent changes* (*memories, optical memory pictures*). *After destruction* of this area, excitation of the optic-nerve fibres either fails to arouse visual sensation of any kind (blindness) or fails to summon forth any recollection of objects or circumstances acquired through previous education; in the latter case, objects are seen but not recognized (*psychical or cortical mind-blindness*).

Each retina is supplied by optic nerve fibres passing to both sides of the brain. Each *optic nerve* is composed of an *external set* of fibres derived from the outer or temporal half of the retina, and an *internal* set derived from the inner or nasal half of the retina. In the axis of the optic nerve is found a *special set of fibres* which pass to the *macula* and the space between it and the disc. These macular fibres, when they reach the eyeball, are collected into a sector corresponding to *the outer third of the disc*, the apex directed toward the centre and the base toward the margin of the papilla. The *external or temporal fibres* are continued

along the lateral part of the chiasm and tract and *pass* to the primary optic centre of the *same side*. The *inner fibres*, derived from the nasal half of the retina, pass into the chiasm and *decussate;* they are continued in the tract of the *opposite side*, thus passing to the *side of the brain opposite* to the eye which they supply.

The chiasm presents *laterally* the direct or *temporal fibres* of both eyes, and *in its centre*, the *decussation of the inner or nasal fibres* of both eyes. Consequently, the decussation in the chiasm is not complete but partial—a *semi-decussation*.

Each optic tract contains fibres from both eyes. The right optic tract consists of non-decussating fibres from the right (temporal) half of the retina of the right eye, and decussating fibres from the right (nasal) half of the left eye. Hence the *right halves of both retinæ and thus the left halves of both visual fields are connected with the right tract* (Fig 137). It follows, therefore, that the visual impulse excited by objects placed to the left of the median line passes to the cortex of the right hemisphere by means of the right optic tract; and that the perception of all objects placed to the right of the median line is conveyed by the left optic tract to the cortex of the left hemisphere.

Hemiopia.—This arrangement of fibres in the chiasm explains the occurrence of a form of visual disturbance known as *hemiopia* (*hemianopia*, *hemianopsia*) by which we mean the *loss of vision for corresponding halves or sectors of the visual fields*. If a lesion interrupts the continuity of the right optic tract, the right cortical visual area, or any portion of the visual path between these parts, there will be blindness of the right halves of both retinæ; as a result, the left halves of the fields of vision of both eyes will be lost, and only objects which are placed to the right of the median line will be perceived. This is known as *homonymous or lateral hemiopia*, and in this particular case the condition is called *left* homonymous hemiopia, be-

cause the left halves of the fields of vision are wanting. *Homonymous hemiopia* (Fig. 138), therefore, always points to a lesion situated in the visual path or cortex on the *central side of the chiasm* and upon the *same side as the blind halves of the retinæ*. It is the commonest form of hemiopia.

If a lesion extends antero-posteriorly through the chiasm it will destroy all the *decussating fibres* of both retinæ

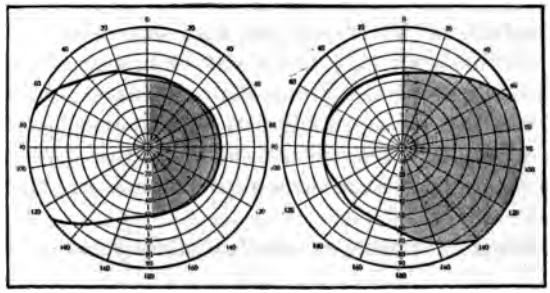


FIG. 138.—The Fields of Vision in Right Homonymous Hemiopia.

which supply the *inner or nasal halves*, and there will be a loss of vision in the outer or temporal halves of the field of both eyes, a condition called *bitemporal hemiopia* (4, Fig. 137). It is seen in acromegaly.

If a lesion attacks each side of the chiasm, it will destroy the *non-decussating fibres* which come from the temporal halves of the retinæ, and will, therefore, cause a loss of the nasal or inner half of the field of vision of each eye; this is known as *binasal hemiopia*. *Bitemporal* and *binasal* hemiopia are known as *crossed hemiopia*. These forms are rare, as will be inferred when the situation of the lesion necessary to produce them is considered; it is doubtful whether binasal hemiopia ever occurs. Another rare form of hemiopia is altitudinal (inferior or superior)—when the upper or the lower half of each field is wanting.

Hemiopia is said to be *complete* when there is a *symmet-*

rical absence of the entire half of the field of vision. It is *incomplete* when there is an *absence of a small portion or sector* occupying a *symmetrical* position in the visual fields of the two eyes; the lesion then involves only a portion of the fibres of a visual tract or cortical visual area.

Even in cases of complete hemiopia, the line between the absent and the preserved portion of the field seldom extends through the fixation point, the portion of the field corresponding to the *macula* being usually *preserved.* When both halves of the fields are lost successively (double homonymous hemiopia), there will be blindness except at the situation of these macular fibres. This occurrence has been explained by supposing (1), that the macula receives fibres from both hemispheres, and (2), that the cortical centre for the macula receives a special and abundant blood supply.

Hemiopia is known as *absolute* when there is *loss of light, form, and color sense,* and *relative* when only the *color sense* or both the color sense and form sense are *destroyed* over the symmetrically defective areas, while the *light sense remains relatively intact.* This is known as *hemiachromatopsia ;* it was formerly believed to indicate the existence of separate cortical centres for color, form, and light perception, but is now explained by assuming the existence of a *lesion of less intensity* than that which causes absolute hemiopia.

Complete blindness in one eye only is always due to a lesion situated *in front of the chiasm.* The same applies to *scotomata,* which are defects in the visual field of one eye (p. 15), or non-symmetrical defects in the fields of both eyes; when central, they indicate an involvement of the papillo-macular sector of the optic nerve.

The Hemiopic Pupillary Reaction (*Wernicke*) may be of value in determining whether a lesion causing homonymous hemiopia is *situated behind or in front of the primary optic ganglia. If behind* this point, the *pupillary light reflex*

will be preserved; if in front of these ganglia (in the optic tract) it may be diminished when the blind half of the retina is illuminated (Fig. 89). This test is very difficult to apply in a conclusive manner.

Scintillating Scotoma (*Transient Hemiopia*) is a form of *temporary blindness* generally associated with *migraine* and probably due to a *circulatory disturbance in the occipital lobe.* The *attack* begins with a central *dark spot* before both eyes, which spreads by *scintillating* and colored zigzag *lines* until there is a considerable *gap in the field,* often *hemianopic.* Accompanying the attack there are *headache, general malaise, vertigo,* and sometimes nausea and vomiting. The attacks vary in frequency and last about fifteen minutes, after which the amblyopia disappears entirely. The affection occurs after *excessive mental or physical exertion* and following marked *eye strain.* Unless associated with paralysis, aphasia, or other symptoms of cerebral trouble, it is *not of serious import. Treatment* consists in *attention to the general health, avoidance of fatigue* of any kind, and the use of remedies suited to *migraine.*

CHAPTER XXI.

GENERAL OPTICAL PRINCIPLES.

From a luminous point, *rays of light pass out in straight lines in every plane and in every direction;* the lines of direction are called *rays.* These travel with a rapidity which diminishes with the density of the medium traversed.

The amount of divergence of the rays of light falling on a given area is proportionate to the distance of the luminous source; the nearer this point, the more divergence. When proceeding from a point distant *twenty feet or more,* the divergence of rays is so slight, that for practical purposes we may assume them to be *parallel.*

When a ray of light meets an *opaque* body, it is either *absorbed* or *reflected.* When it meets a *transparent medium,* some of it is absorbed and reflected, but the greater part *traverses* the medium, being *deflected* in its course; this *bending* is called *refraction.*

REFLECTION.

Reflection occurs from any *polished surface* (*mirror*)—plane, concave, or convex. The ray striking the mirror is called the *incident ray* (*IB*, Fig. 139); that returning from the mirror, the *reflected ray* (*BR*, Fig. 139).

Laws of Reflection: (1) The angle of reflection is equal to the angle of incidence. (2) The reflected and incident rays are both in a plane perpendicular to the reflecting surface. In Fig. 139, *IB* is the incident ray on the reflecting surface *AC*, *BR* the reflected ray, and *PB* the perpendic-

ular. The angle of incidence, *IBP*, is equal to the angle of reflection, *PBR*. *IB*, *PB*, and *BR* lie in the same plane.

Reflection by a Plane Mirror.—The image is formed at a distance behind the mirror equal to the distance of the object in front of it; it is a *virtual* image, *erect*, and of the *same size* as the object. In Fig. 140, *O* is the object, *I* the image, and *E* the eye of the observer. The image of the candle *O* is found behind the plane mirror *MM*; the observer's eye *E* receives the rays from *O* as if they came from *I*.

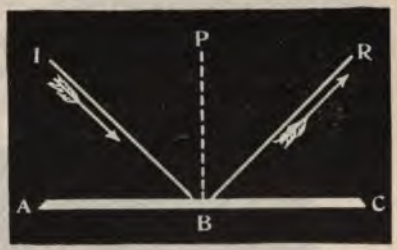


FIG. 139.—Reflection by a Plane Surface.

Reflection from a Concave Mirror.—A concave surface may be considered as made up of a number of plane surfaces inclined toward one another. *Parallel rays* falling on a concave mirror are *reflected as convergent rays* which meet on the axis of the surface at a point called the *principal focus* (*Pf*, Fig. 141); the latter is midway between the mirror and its optical centre *C*. The distance of the principal focus from the mirror is called the *focal length* of the mirror.

FIG. 140.—Formation of Image by a Plane Mirror.

The *position of an image* formed by a concave mirror varies with the distance of the object from the mirror. If the object be placed at the principal focus, *Pf*, the reflected rays are parallel to each other and to the axis of the mirror. If the object be placed at the centre of concavity *C*, the reflected rays return along the same lines. If the ob-

ject is beyond the centre, at *CF*, the reflected rays focus between the centre and the principal focus at *cf*; and conversely, if the object be moved between the principal focus and the centre, at *cf*, its focus will be beyond the centre, at *CF*; these two points, *CF* and *cf*, bear a reciprocal relation to each other and are known as *conjugate foci*; the nearer the object approaches the principal focus, the greater the distance at which the reflected rays meet. If the ob-

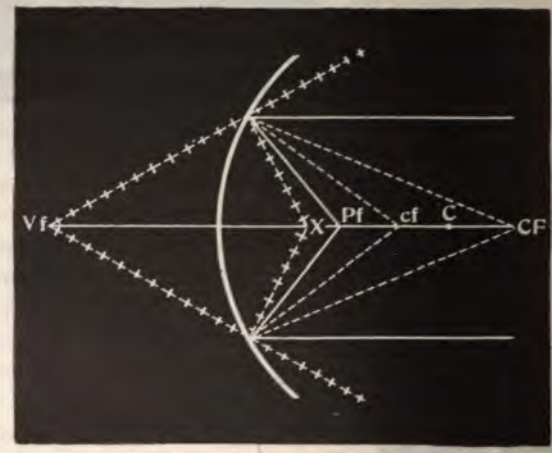


FIG. 141—Reflection by a Concave Mirror.

ject be placed nearer the mirror than the principal focus, at *X*, reflected rays will be divergent and never meet; if, however, these divergent rays are continued backward, they will unite at a point *Vf*, behind the mirror; this point is called the *virtual focus*, and an observer placed in the path of the reflected rays will receive them as though they came from this point.

It follows, therefore, that *concave mirrors* produce an enlarged, erect, and virtual image if the object is placed nearer than the principal focus; no image of an object placed at the principal focus; an enlarged, inverted, real

image if the object is placed between the principal focus and the centre; an inverted image of the same size when placed at the centre; and a smaller, inverted, real image if the object is placed beyond the centre.

FIG. 142.—Reflection by a Convex Mirror.

Reflection by a Convex Mirror.—All rays falling on a convex surface are reflected *divergent* and hence never meet; but if prolonged backward a *negative image* is formed at a point called the *principal focus* (Fig. 142, *F*). The image is always *virtual*, *erect*, and *smaller* than the object, independent of the position of the object before the mirror.

REFRACTION.

Refraction is the *deviation* in the course of rays of light in passing from one *transparent* (dioptric) *medium* into another of *different density* (*refracting medium*). The ray which falls *perpendicular* to the surface separating the two media is *not refracted* but continues in a straight course (Fig. 143, *PP*).

FIG. 143.

FIG. 144.

FIG. 143.—Passage of a Perpendicular Ray Through a Transparent Medium.

FIG. 144.—Refraction by a Transparent Medium with Parallel Surfaces.

In passing from a *rarer to a denser medium*, a ray is *refracted toward the perpendicular* to the refracting surface; in passing *from a denser to a rarer medium*, the ray is *refracted away from the perpendicular*. In Fig. 144, the incident ray *IR*, in

passing from a rarer medium (air) into a denser medium (glass), is refracted toward the perpendicular *PP;* in passing from a denser to a rarer medium, the emergent ray *ER* is refracted from the perpendicular *PP*. The ray continues in a line parallel to *its original course*, but has suffered *lateral deviation*. The angle formed by the incident ray with the perpendicular, *IRP*, is known as the *angle of incidence;* the angle formed by the emergent or refracted ray with the perpendicular, *PER*, is known as the *angle of refraction*.

Index of Refraction.—The *relative density*, or the comparative length of time occupied by light in travelling a definite distance in different transparent media is known as the *index of refraction*. Air being taken as 1.00, the index of refraction of water is 1.33, of the cornea 1.33, of the lens 1.40, of crown glass 1.5, of flint glass 1.6, and of diamond 2.50.

PRISMS.

A prism is a piece of glass or other refracting substance bounded by *plane surfaces inclined toward each other* (Fig. 145). The angle formed by the two surfaces is called the *refracting angle* of the prism (*BAC*), the *thin edge* where the intersecting surfaces meet is known as the *apex* (*A*), and the opposite *thick portion* as the *base* (*BC*).

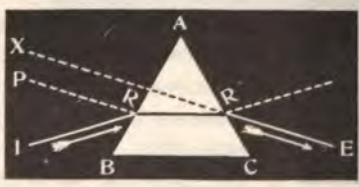


FIG. 145.—Refraction by a Prism.

Refraction by a Prism.—Rays of light passing through a prism are *bent toward the base*. In Fig 145, the incident ray *IR* is refracted toward the perpendicular *PR*, at *R*, and assumes the direction *RR* in the prism; on emerging, it is refracted away from the perpendicular and continues as *RE* toward the base of the prism. To the eye

placed at *E*, the ray *RE* seems to come from *X*; hence *an object seen through a prism appears displaced toward the apex.* A prism has neither converging nor diverging power and therefore has no focus and cannot form an image; rays that are parallel before entering the prism are parallel on emerging (Fig. 146).

FIG. 146.—Passage of Parallel Rays Through a Prism.

The Numbering of Prisms.—The *strength of a prism* is expressed (1) in degrees, (2) in centrads, and (3) in prism-diopters. In the first method (*degrees*), which in spite of certain faults is the one *most generally used*, the value of the prism *corresponds to the refracting angle* (*geometrical* angle) and is expressed: Prism 1°, 2°, 10°, etc. A *centrad* corresponds to a deviation, the arc of which is $\frac{1}{100}$ of the radius, and is expressed 1^{∇}, 2^{∇}, 10^{∇}, etc. The *prism diopter* is a deviation, the tangent of which is $\frac{1}{100}$ of the radius, and is expressed: 1 P. D. or 1^{Δ}, 2 P. D. or 2^{Δ}, etc. Within the limits of common use, the *three scales* can practically be considered *alike.*

The Position of a Prism when placed in front of an eye is indicated by the *direction of its base;* "base out" means that the thick part of the prism is toward the temple; the base may be up, down, in, or out.

The Uses of Prisms: (1) To counteract the effects of muscular paralysis or insufficiency; (2) for the exercise of weak muscles; (3) to test the strength of eye muscles; (4) as a test for muscular insufficiency; (5) for detecting simulated blindness.

LENSES.

A *lens* is a transparent *refracting medium*, usually made of *glass*, in which one or both *surfaces are curved*. There are two kinds: *spherical and cylindrical* lenses.

FIG. 147.—The Relation of the Surfaces of Lenses to Spheres. 1. Plano-convex; 2, biconvex: 3, convex meniscus; 4, plano-concave; 5, biconcave; 6, concave meniscus.

Spherical Lenses (abbreviated Sph. or S.) are so called because the curved surfaces are *segments of spheres* (Fig. 147); such lenses refract rays of light equally in *all meridians* or planes. There are two kinds of spherical lenses, *convex and concave*.

Spherical lenses may be considered as *made up of a number of prisms* (Fig. 148). In *convex* lenses the prisms are placed with their *bases together;* in *concave* lenses the *apices* of the prisms are *together*.

Convex Spherical Lenses are formed of prisms with their bases together and toward the centre (Fig. 148, *A*); they are therefore *thick at the centre* and thin at the edge. They are known as *converging*, magnifying, positive, and *plus* lenses, and denoted by the *sign* +. They have the power of *converging parallel rays* and of bringing them to a *focus* (Fig. 151). There are *three different forms:* (1) *Plano-convex*, one surface plane, the other convex (1, Fig. 149); (2) *biconvex* or double convex, both surfaces convex (2, Fig. 149); (3) *concavo-convex (convex periscopic*, convex or converging *meniscus*), one sur-

A B

FIG. 148.—The Formation of Lenses by Prisms.

face convex, the other concave—the former having the shorter radius of curvature (3, Fig. 149). The *periscopic* lens (whether + or −) diminishes spherical aberration and enlarges the field of vision.

FIG. 149.

FIG. 150.

FIG. 149.—Convex Lenses. 1, Plano-convex; 2, biconvex; 3, convex meniscus.

FIG. 150.—Concave Lenses. 1, Plano-concave; 2, biconcave; 3, concave meniscus.

Concave Spherical Lenses are formed of prisms with their apices together and toward the centre (Fig. 148, *B*); they are therefore *thin at the centre* and thick at the edge. They are known as *diverging*, reducing, negative, or *minus* lenses, and denoted by the sign −. Rays of light after passing through a concave lens are rendered *divergent;* if prolonged backward they form an image on the same side as the object (Fig. 152). There are *three different forms:* (1) *Plano-concave*, one surface plane, the other concave (1, Fig. 150); (2) *biconcave* or double concave, both surfaces concave (2, Fig. 150); (3)

FIG. 151.—The Action of a Convex Lens on Parallel Rays.

FIG. 152.—The Action of a Concave Lens on Parallel Rays.

convexo-concave (*concave periscopic*, concave or diverging *meniscus*), one surface convex and the other concave, the latter having the shorter radius of curvature (3, Fig. 150).

The Action of Spherical Lenses.—Since spherical lenses

are formed of prisms with their bases (convex) or apices (concave) in apposition, and since rays in passing through a prism are refracted toward its base, it follows that *convex lenses cause convergence* (Fig. 151), and *concave lenses produce divergence* of rays (Fig. 152).

FIG. 153. — Principal and Secondary Axes of a Convex Lens.

A line passing through the centre of the lens (optical centre or nodal point, *O*, Fig. 153) at right angles to the surfaces of the lens is called the *principal axis* (*AB*, Fig. 153). A ray passing through this axis (*axial ray*) is *not refracted;* all other rays suffer more or less refraction. Rays passing through the optical centre of a lens, but not through the principal axis (*secondary rays*) are *slightly deviated*, but emerge in the *same direction* as they entered (*CD* and *EF*, Fig. 153); the deviation in thin lenses is so slight, that practically they may be considered as straight lines and are called *secondary axes.*

Foci of a Convex Lens.—The point to which rays converge after refraction by a convex lens is called its *focus.* The *principal focus* is the *focus for parallel rays* (*F*, Fig. 154); the distance of this point from the optical centre is called the *focal distance* of the lens (*XF*, Fig. 154). Since the course of a ray passing from one point to another is the same, independent of the direction, it follows that rays from a luminous point placed at the *principal focus* will emerge as *parallel* after passing through the lens.

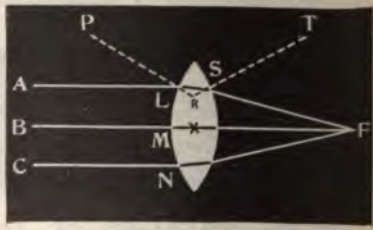


FIG. 154.—The Principal Focus of a Convex Lens.

In Fig. 154, the rays *ABC* strike the surface of the lens at *LMN;* the axial ray *B* strikes the lens at *M* perpendicu-

lar to its surface and consequently continues in a straight line to *F*. The ray *A* strikes the lens obliquely at *L* and is bent toward the perpendicular of the surface of the lens at that point, shown by the dotted line *PR*; on leaving the lens obliquely at *S* it is deflected away from the perpendicular *RT*, being directed to *F* where it meets the axial ray *BF*. The ray *C* is refracted in a similar manner; it is bent upon entering the lens at *N* and rendered additionally convergent when emerging from the lens, and finally it meets the other rays at *F*. If, in this same illustration, the rays proceed from *F*, the principal focus, they emerge parallel (*LA*, *MB*, *NC*) after passing through the lens.

Conjugate Foci of a Convex Lens.—Conjugate foci are *interchangeable foci* in which the image can be replaced by the object and the object by the image. When divergent rays (*i.e.*, rays coming from a point nearer than twenty feet) proceed from a point beyond the principal focus, they will meet at a point beyond the principal focus on the other side of the lens. The more distant the luminous point the nearer the principal focus on the other side of the lens will the rays be focussed. If the luminous point is situated at

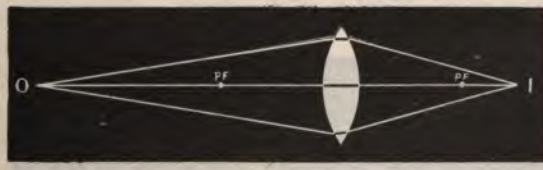


FIG. 155.—Conjugate Foci of a Convex Lens.

a distance equal to twice the focal length of the lens, the rays will focus at the same distance on the opposite side. These are *conjugate foci*.

In Fig. 155, the rays diverging from *O* and passing through the lens converge at *I*; if they diverge from *I*, they would return in the same path and meet at *O*; the

points O and I are conjugate foci. In the preceding example the conjugate focus is *positive or real*.

Virtual or Negative Focus of a Convex Lens.—When rays diverge from some point between the lens and its principal focus (Fig. 156, O), they will continue divergent after refraction, but less so than before entering the lens; if prolonged backward they will meet at a point (I, Fig. 156) on the same side of the lens from which they diverged; this point is a *negative or virtual focus*.

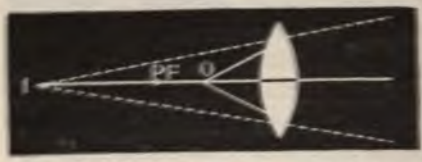


FIG. 156.—Virtual Focus of a Convex Lens.

Foci of a Concave Lens.—After passing through a concave lens, rays of light, whether originally parallel or divergent, are *always divergent* and the *focus* is, therefore, *always negative or virtual;* it is found by continuing these divergent rays backward until they meet at a point (Fig. 152).

Formation of Images.—The *image* of an object formed by a lens is a *collection of foci*, each corresponding to a

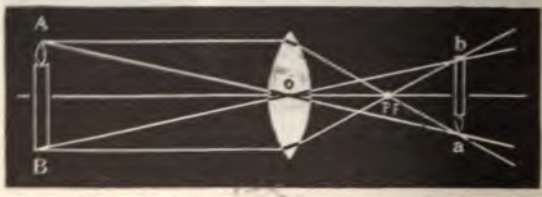


FIG. 157.—Real, Inverted and Reduced Image Formed by a Convex Lens.

point in the object. Such images are either *real or virtual*. A *real image* is formed by the *meeting of rays;* it can be projected on a screen. A *virtual* image is formed by the *prolongation backward of diverging rays* until they meet

at a point; it can only be seen by looking through the lens.

To find the position and size of an image formed by a lens, it is necessary to obtain the conjugate focus of each

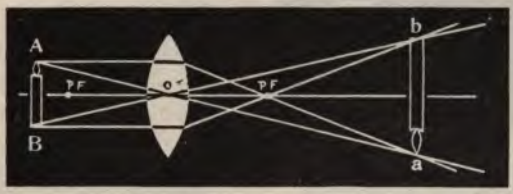


FIG. 158.—Real, Inverted and Enlarged Image Formed by a Convex Lens.

extremity of the object: Two lines are drawn from each of these points, one parallel to the axis of the lens and then through the principal focus, and the other through the optical centre; the image will be formed at the point where these rays intersect (Figs. 157, 158, 159).

In Fig. 157, AB is the object, O is the optical centre of the lens, and PF its principal focus. From A, two rays are drawn, one parallel to the axis of the lens and then through the principal focus PF, and a secondary ray through O; the image of the point A is formed at a, where these two lines intersect. The conjugate focus of B is found in the same manner.

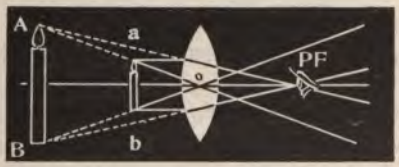


FIG. 159.—Virtual Image Formed by a Convex Lens.

The relation in size between image and object depends upon their respective distances from the optical centre of the lens. In Fig. 157, the object is placed at a greater distance than twice the principal focus, hence the image is real, inverted, and smaller. If the object is situated at exactly twice the distance of the principal focus,

the image will be real, of the same size, and inverted. If the object is situated just beyond the principal focus, the image will be real, enlarged, and inverted (Fig. 158). If the object be placed at the principal focus, the rays will be parallel after refraction and no image will be obtained. If the object be nearer than the principal focus, the rays will be divergent after passing through the lens (Fig. 159) and no real image will be formed; but by projecting these rays backward they would meet, and an eye placed at *PF*, Fig. 159, will receive the rays from *ab* as if they came from *AB;* the image will be enlarged, erect, and virtual; it is on the same side of the lens as the object, and is seen only by looking through the lens, which acts as a *magnifying glass.*

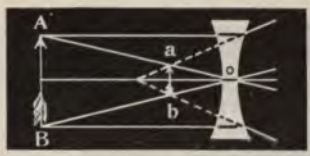


FIG. 160.—Virtual Image Formed by a Concave Lens.

Images formed by concave lenses are always virtual, erect, and smaller than the object; they are seen only by looking through the lens, which acts as a *reducing glass* (Fig. 160).

Cylindrical Lenses.—A cylindrical lens or *cylinder* (abbreviated Cyl. or C.), is a *segment of a cylinder parallel to its axis* (Fig. 161). Cylinders are divided into *convex and concave.* Light passing through a cylinder *in the plane of its axis is not refracted* and behaves exactly as though passing through a plate of glass with parallel sides; in this direction, the surface of the lens is straight. But when light passes through in a *plane opposite* or perpendicular *to the axis* of a cylinder,

FIG. 161.—The Construction of a Convex and a Concave Cylindrical Lens from a Cylinder.

the *rays are rendered convergent or divergent*, according as the cylinder is convex or concave; in this direction the surface of the lens is curved. Parallel rays of light after refraction by a cylinder are focussed in a straight line which corresponds to the axis of the cylinder (Figs. 162, 163). A *spherical* lens refracts equally in *all planes;* a *cylindrical* lens does not refract in the axial plane, but all other rays are refracted, those the most which pass at right angles to its axis. It is necessary to *indicate the*

FIG. 162.—The Action of a Convex Cylindrical Lens upon Parallel Rays.

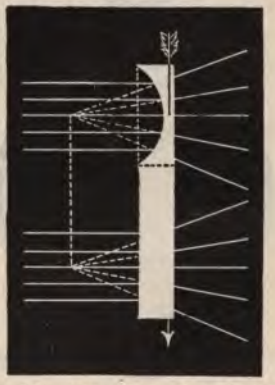


FIG. 163.—The Action of a Concave Cylindrical Lens upon Parallel Rays.

direction of the axis of a cylinder; in the lenses of the trial case, used for the estimation of the refraction of the eye, this is done by a short linear scratch on the lens at its margins or by having a portion of the surface on each side ground parallel to its axis (Fig. 165).

The Numeration of Lenses.—The *strength* of a lens refers to its power of bringing parallel rays to a focus—*i.e.*, its *refractive power;* this is indicated by its *principal focal distance*, the interval between the optical centre of the lens and the principal focus. The shorter this distance, the stronger the lens; the greater the principal focal

distance, the weaker the lens. *The strength of a lens is the inverse of its focal distance.*

There are *two systems of numbering lenses:* (1) The Inch, and (2) the Metric or Dioptric.

In the Inch System, the *unit* is a strong lens which brings parallel rays to a focus at one inch; this is known as $\frac{1}{1}$ or 1, and every other lens is a *fraction* of this unit, in which the *focal distance* in inches forms the *denominator*. For

FIG. 164.—Spherical Lens from Trial Case.

FIG. 165.—Cylindrical Lens from Trial Case.

instance, $\frac{1}{4}$ has a focal distance of 4 inches, $\frac{1}{10}$ of 10 inches, $\frac{1}{40}$ of 40 inches. Such lenses are also expressed by the terms No. 4, No. 10, No. 40, indicating their focal strength. This system, though very simple, is open to the objections (1) that the inch varies in length in different countries, (2) the lack of uniform intervals, and (3) the inconvenience of adding or subtracting vulgar fractions in practical work.

The Metric or Dioptric System accepts as its *unit* a lens which has its principal focus at *one metre* distance ($39\frac{1}{3}$ English inches, in round numbers 40 inches); this lens is known as 1.00 *diopter* (abbreviated D.). Every lens is numbered by its strength in *whole numbers and in decimal fractions* (0.25, 0.50, 0.75). A lens which has twice the

strength of the unit is known as 2 D.; its focal distance is one-half of a metre. If the lens has a strength four times that of the unit, it is called 4 D., and its focal distance is one-quarter of a metre. If ten times as strong as the unit, it is known as 10 D., and its focal distance is one-tenth of a metre. If one-quarter, one-half, or three-quarters as strong as the unit, it is known as 0.25 D., 0.50 D., or 0.75 D. respectively. In this system the number of the lens does not express its focal distance; but the focal distance in centimetres is obtained by dividing 100 cm. by the number of the lens; for example a 2 D. lens has a focal distance of $\frac{100}{2} = 50$ cm.; a 5 D. lens has a focal distance of $\frac{100}{5} = 20$ cm. The *dioptric system* is the one now *universally adopted.*

To convert the focal distance in inches into the focal distance in diopters, divide the number 40 by the number of inches or diopters expressed. For example, 8 D. $= \frac{40}{8} = 5$ inches $= \frac{1}{5}$; 0.50 D. $= \frac{40}{5} = 80$ inches $= \frac{1}{80}$; $\frac{1}{20}$ (twenty inches) $= \frac{40}{20} = 2$ D.; $\frac{1}{10}$ (ten inches) $= \frac{40}{10} = 4$ D. The following table gives the commonly employed (approximate) *equivalents* in the inch and the dioptric systems:

COMMONLY EMPLOYED (APPROXIMATE) EQUIVALENTS OF LENSES NUMBERED IN THE DIOPTRIC AND INCH SYSTEMS.

Diopters.	Inches.	Diopters.	Inches.	Diopters.	Inches.	Diopters.	Inches.
0.25	160	2.25	18	5.50	7.0	13	3.0
0.50	80	2.50	16	6.00	6.5	14	2.8
0.75	50	2.75	14	7.00	5.25	15	2.6
1.00	40	3.00	13	8.00	5.0	16	2.4
1.25	32	3.50	11	9.00	4.5		
1.50	26	4.00	10	10.00	4.0	18	2.2
1.75	22	4.50	9	11.00	3.5		
2.00	20	5.00	8	12.00	3.3	20	2.0

The Trial Case (Fig. 166) is a flat box containing + and − spherical, and + and − cylindrical lenses, arranged in pairs. The spherical lenses (Fig. 164) usually correspond to those given in the preceding table (30 pairs), the

weaker ones separated by intervals of 0.25 D., those of moderate strength by 0.50 D., and the stronger ones by 1 D. The cylindrical lenses (Fig. 165) usually run from 0.25 D. to 6.00 D. The + lenses are mounted in nickelled rims, the − lenses in brass rims. Besides these lenses, a complete trial case contains a set of prisms, various metal

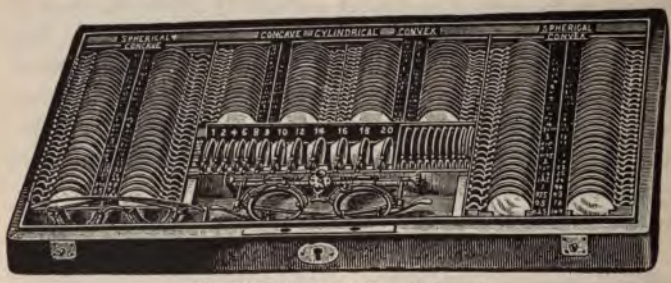


FIG. 166.—The Trial Case of Lenses.

discs one of which (obturator) is solid and is used to exclude one eye in the examination, and a trial spectacle frame (Fig. 176).

Recognition of the Kind of Lens and Estimation of its Strength.—By moving a *spherical lens* before the eye and looking at an *object*, the latter will appear to *move*, rapidly if the lens is a strong one, slowly if a weak one. If the object seems to move in the *opposite direction* and appears *enlarged*, the lens is *convex*. If the object appears to move in the *same direction* and seems *smaller*, the lens is *concave*.

When a *cylinder* is moved before the eye in the direction of its *axis*, an object looked at does not appear to change its position; when moved in the *opposite direction*, objects appear to move as with spherical lenses—in the opposite direction when the cylinder is convex, in the same direction when concave.

Having recognized the character of the lens, the *strength* can be determined by *neutralizing*. Lenses of opposite

kind and known strength are taken from the trial case and placed in front of the one to be tested, and the two lenses moved in front of the eye. The neutralizing lens is the one which *stops all apparent movement* of an object looked at, when the combined lenses are moved in front of the eye. The Geneva Lens Measure (Fig. 167) furnishes a very quick and reliable method of determining the character and strength of any lens.

Finding the Centre of the Lens.—Unless especially desired (for prismatic effect) the optical centre of the lens should coincide with the geometric centre. To find the optical centre we look at two lines at right angles to each other through the lens held a few inches above. The portion of the vertical and of the horizontal line seen through the lens is made continuous with the portion seen beyond the lens; then the two lines should cross at the geometrical centre of the lens.

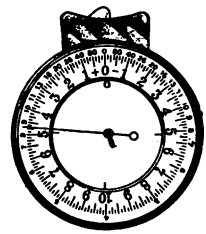


FIG. 167.—Geneva Lens Measure.

Varieties of Lenses Used to Correct Errors of Refraction: 1. Simple spherical lens, convex or concave. 2. Simple cylindrical lens, convex or concave. 3. Sphero-cylinder, a combination of a spherical with a cylindrical lens. 4. Cross-cylinder, a combination of two cylindrical lenses with their axes at right angles to each other (infrequently used). 5. Simple prism. 6. Prism combined with various lenses.

Abbreviations and Signs.—The following are in *general use in ophthalmology:*

A. or Acc.....Accommodation.
Am .....Ametropia.
As .....Astigmatism, astigmatic.
As. H.....Hyperopic astigmatism.
As. M .....Myopic astigmatism.
Ax.....Axis (of cylindrical lens).
B.....Base (of prism).

C. or Cyl.....Cylindrical lens or cylinder.
cm.....Centimetre.
D.....Diopter.
E. or Em.....Emmetropia or emmetropic.
H .....Hyperopia, hyperopic, horizontal.
Hl.....Hyperopia latent.
Hm.....Hyperopia manifest.
Ht .....Hyperopia total.
M. .....Myopia or myopic.
m.....Metre.
M. A.....Metre angle.
mm .....Millimetre.
n.....Nasal.
O. D. (R., or R. E.)...Oculus dexter (right eye).
O. S. (L., or L. E.)....Oculus sinister (left eye).
O. U .....Oculus utrique (both eyes).
P. p .....Punctum proximum (near point).
P. r .....Punctum remotum (far point).
Pr ....Presbyopia.
S. or Sph .....Spherical lens.
t.....Temporal.
T .....Tension.
V.....Vision, visual acuteness, vertical.
w .....With.
+.....Plus or convex.
− .....Minus or concave.
= ....Equal to.
⊂.....Combined with.
∞.....Infinity (20 feet or more distance).

CHAPTER XXII.

OPTICAL CONSIDERATION OF THE EYE.

THE eye may be considered as an optical instrument, often compared to the photographic camera, in which by means of a *refracting* (*dioptric*) *system* a *small and inverted image* of external objects is formed *on the retina*. The impression received by the rods and cones is conveyed through the optic nerve to the *visual cortical area* where the visual act is completed and results in the sense of *sight*.

The eye is well adapted for its function of refraction. It is *spherical* in shape, about 24 mm. in diameter, and *protected externally* by the opaque sclera behind and the transparent cornea in front. The outermost portion of the retina consists of a layer of *pigment cells* which absorbs the excess of light and prevents dazzling.

Dioptric Apparatus of the Eye.—In passing through the eyeball, rays of light traverse the cornea, aqueous humor, lens, and vitreous. The *refracting surfaces* of the eye are the cornea, the anterior surface and the posterior surface of the lens; the *refracting media* are the aqueous humor, the substance of the lens, and the vitreous. These surfaces and media constitute the *dioptric or refractive apparatus of the eye*, a system which is represented by a convex lens of 23 mm. focus; hence in an emmetropic eye in a condition of rest, parallel rays are brought to a focus on the retina. The greatest deflection of rays takes place at the anterior surface of the cornea; additional deviations occur at the anterior and posterior surfaces of the lens. In each case the effect is one of *convergence*. By the term

refraction of the eye, we mean the changes which the transparent ocular media exert upon rays of light when the eye is in a *state of rest*.

Cardinal Points of the Eye.—It is necessary to be acquainted with the cardinal points of the eye (Fig. 168) in order to understand the course of rays of light through this organ; they are the two principal points, the two nodal points, and the two principal foci, all situated on the optical axis.

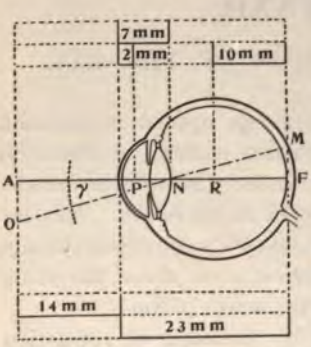


FIG. 168.—Cardinal Points of the Eye.

The Principal Points (*P*, Fig. 168) are two points so related that when an incident ray passes through the first principal point, the corresponding emergent ray passes through the second principal point. These two points are placed so close together in the anterior chamber that they may be considered as one point, situated about 2 mm. behind the cornea.

The Nodal Points (*N*, Fig. 168) correspond practically to the optical centre of the dioptric system; they are so close together that they may be considered as one point situated near the posterior pole of the lens about 7 mm. behind the cornea. Rays passing through this point are not refracted and form either the axial or secondary rays.

The First Principal Focus (*A*, Fig. 168) is that point on the axis at which parallel rays in the vitreous meet; it is situated about 14 mm. in front of the cornea.

The Second Principal Focus (*F*, Fig. 168) is that point on the axis at which parallel rays meet after being refracted by the dioptric system of the eye; it is situated to the inner side of the macula, between it and the optic disc, about 23 mm. behind the cornea.

The Centre of Rotation of the eyeball (*R*, Fig. 168) is situated in the vitreous, about 10 mm. in front of the retina.

The Optical Axis (*AF*, Fig. 168) is the line connecting the centre of the cornea, the nodal point, and the posterior principal focus on the retina.

The Visual Line (*OM*, Fig. 168) is the line passing from the object looked at, through the nodal point, to the macula.

The *Line of Fixation* is the line joining the object looked at with the centre of rotation; practically it corresponds to the visual line.

The Angle Gamma (γ, Fig. 168) is the angle formed by the optical axis with the line of fixation (practically with the visual line); it varies with the refraction of the eye, being about 5° in emmetropia, larger in hyperopia, and smaller in myopia.

The Angle Alpha is the angle formed by the visual line with the major axis of the corneal ellipse.

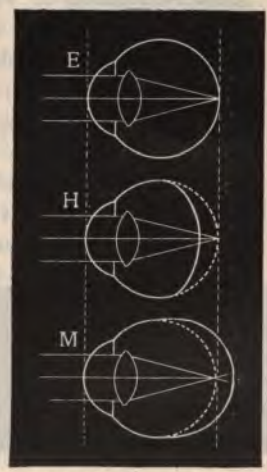


FIG. 169.—Emmetropia.
FIG. 170.—Hyperopia.
FIG. 171.—Myopia.

REFRACTION OF THE EYE.

Emmetropia.—When parallel rays are focussed exactly on the retina with the eye in a condition of rest, the refraction of the eye is normal or *emmetropic* (Fig. 169) and the condition is known as emmetropia (abbreviated E.).

Ametropia.—When, with the eye in a condition of rest, parallel rays are *not focussed on the retina*, but behind or in front of it, the eye is *ametropic*, and the condition is known as ametropia. The forms of ametropia (*errors of refraction*) are *hyperopia*, *myopia*, and *astigmatism*.

Hyperopia (*Hypermetropia or Farsightedness*, abbreviated H.) is that form of ametropia in which the *axis of the eyeball is too short* or the refractive power of the eye too weak, so that *parallel rays* are brought to a *focus behind the retina* (Fig. 170).

Myopia (*Nearsightedness*, abbreviated M.) is that form of ametropia in which the *axis of the eyeball is too long* or the refractive power too strong, so that *parallel rays are focussed in front of the retina* (Fig. 171).

Astigmatism (abbreviated As.) is that form of ametropia in which the *refraction of the several meridians* of the eyeball is *different* (Figs. 196–200).

The Acuteness of Vision and the method of its determination for distance and near have been described with the functional examination of the eye in Chapter II.

ACCOMMODATION.

Accommodation is the *power of altering the focus of the eye* so that divergent rays (those coming from an object nearer than 20 feet) are brought together on the retina;

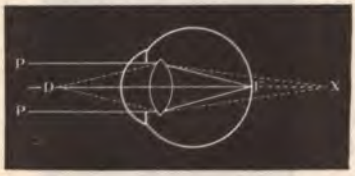


FIG. 172.—The Emmetropic Eye in a State of Rest.

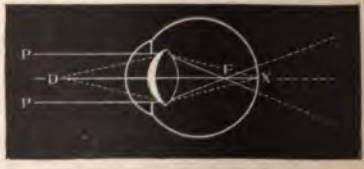


FIG. 173.—The Emmetropic Eye During Accommodation.

this is accomplished by means of an *increase in the convexity of the lens* and thus in its refractive power. The degree of accommodation must *vary for every distance* of the object; the eye cannot be adapted for two different distances at the same time.

In the *emmetropic eye at rest, parallel rays* are brought to

a *focus* on the *retina* (*PF*, Fig. 172), but rays coming from a near object (*divergent rays*) are *focussed behind the retina* (*DX*, Fig. 172); hence distant objects appear distinct and near objects blurred. If the refractive power of the eye is increased by *accommodation*, parallel rays will be brought to a focus in front of the retina (*PF*, Fig. 173), while *divergent rays* will be *focussed on the retina* (*DX*, Fig. 173); consequently near objects appear distinct and distant objects appear blurred during accommodation.

FIG. 174.—Section of the Anterior Portion of the Eyeball. The dotted lines illustrate the changes during accommodation.

Mechanism of Accommodation.—The *lens* is an elastic structure, and when released from the flattening influence of its suspensory ligament *tends to assume a spherical shape.* During accommodation, the *ciliary muscle* (especially the circular fibres) *contracts*, drawing forward the chorioid and *relaxing the suspensory ligament;* this diminishes the tension of the lens capsule and allows the inherent elasticity of the lens to *increase its convexity.* The change in curvature affects chiefly the anterior surface of the lens (Fig. 174). This is *Helmholtz's theory* and the one usually accepted. Lately Tscherning has advanced a different theory: He maintains that the ciliary muscle increases the tension of the suspensory ligament during contraction, and that this causes peripheral flattening of the lens with bulging anteriorly at its centre.

The act of accommodation is *accompanied by contraction of the pupil* and (in binocular vision) by *convergence of the visual lines.*

The Far Point.—When the eye is in a state of rest, with accommodation completely relaxed, it is adapted for its far point (*punctum remotum*, abbreviated p. r.). This is

the *farthest point of distinct vision*, and in the *emmetropic* eye it is situated at *infinity* (∞).

The Near Point (*punctum proximum*, abbreviated p. p.) is the *nearest point at which the eye can see distinctly* when employing its maximum amount of accommodation. It *varies* with the amount of accommodation possessed by the eye. The usual plan of *determining* the near point is to note the shortest distance at which the patient can read the smallest test type (Jaeger, No. 1, Fig. 12) with each eye separately.

The Range of Accommodation is the *distance* between the far point and the near point.

The Amplitude of Accommodation is the *difference between the refractive power* of the eye when at *rest* and when the *accommodation* is exerted to the *utmost*. It is *expressed in diopters* representing that convex lens which it would be necessary to place before the eye to take the place of accommodation for the near point.

The amplitude of accommodation in diopters is found by dividing 40 by the distance of the near point in inches, or 100 by the near point in centimetres; for example, if the near point of an emmetropic eye is 8 inches or 20 cm., $\frac{40}{8}$ or $\frac{100}{20} = 5$ D. = amplitude of accommodation; this rule applies to *emmetropia*.

In hyperopia some of the accommodation is required for distant vision; hence we find the apparent amplitude of accommodation and then add that lens which enables the patient to see distant objects without his accommodation; for example, if the near point of a hyperopic eye is 8 inches or 20 cm., and the patient is compelled to use 2 D. of accommodation for distant objects, his amplitude of accommodation would be $\frac{40}{8}$ (or $\frac{100}{20}$) $= 5 + 2 = 7$ D. With the same amplitude of accommodation the near point is farther away than in emmetropia, since some of the power of accommodation is expended in adapting the eye for distant objects; and if the near point were the same, the amplitude

of accommodation would be greater in hyperopia than in emmetropia.

In myopia, since a concave lens is necessary to enable the patient to see distant objects clearly, we must deduct the strength of this glass from that the focal length of which equals the distance of the near point from the eye; for example, if the myopia equals 2 D. and the near point is 4 inches or 10 cm., the amplitude of accommodation will be $\frac{40}{4}$ or $\frac{100}{10} = 10$ D. $- 2$ D. $= 8$ D. With the same amplitude of accommodation, the near point is closer to the eye in myopia than in emmetropia; and if the near point were the same, the amplitude of accommodation would be less in myopia than in emmetropia.

The power of accommodation gradually diminishes and the near point recedes as age advances, owing chiefly to loss of elasticity of the lens. In the emmetrope at 10 years, the p. p. is at 7 cm.; at 40 years it has receded to 22 cm.; at 60 years to 100 cm.; and at 75 years to infinity, the accommodation being suspended and the p. p. coinciding with the p. r. The following table gives the amplitude of accommodation and the near point at various periods of life. The near point applies only to emmetropic eyes, but the amplitude of accommodation is the same at the same age, whether the eye is emmetropic or ametropic.

Year.	Amplitude of Accommodation in Diopters.	Near Point in Centimetres.	Near Point in Inches.	Year.	Amplitude of Accommodation in Diopters.	Near Point in Centimetres.	Near Point in Inches.
10	14.0	7.0	2.8	45	3.5	28.0	11
15	12.0	8.5	3.3	50	2.5	40.0	16
20	10.0	10.0	4.0	55	1.75	55.0	22
25	8.5	12.0	4.7	60	1.0	100	40
30	7.0	14.0	5.6	65	0.75	133	53
35	5.5	18.0	7.0	70	0.25	400	160
40	4.5	22.0	9.0	75	0.0	∞	∞

Presbyopia.—When the near point has receded to a

distance at which the finer kinds of work become difficult, the condition is known as *presbyopia*. This state is the result of a *physiological process* which affects *every eye* and must not be considered a disease. It is usually said to be present when the near point recedes to a distance of more than 22 cm. (9 inches) from the eye, an event which generally happens *between the fortieth and the forty-fifth years.*

The Association Between Accommodation and Convergence.—The preceding considerations of the subject of accommodation referred to monocular vision or sight with one eye. With *binocular vision* it is necessary to consider *convergence* as well as accommodation, for *these two actions* (together with the contraction of the pupil) *are normally associated.*

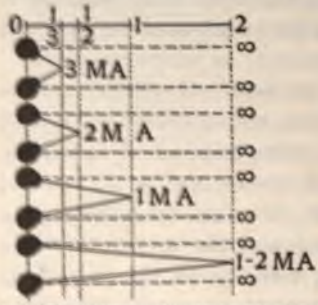


FIG. 175.—Diagram Illustrating the Unit of Convergence, the Meter Angle.

Convergence is the power of directing the visual lines of the two eyes to a near point, and results from the action of the internal recti muscles. When we look at a distant object (situated at 20 feet [6 metres] or beyond), accommodation is at rest and the visual lines are parallel. When we look at a near object, we are compelled both to accommodate and to converge for that distance; *with a certain amount of accommodation, a corresponding effort of convergence of the visual lines is associated.*

The *angle* which the visual line makes in turning from a distant object to a near one is called the *angle of convergence.* The *unit of convergence is the metre angle* (M.A.) which is the angle formed by the visual line with the median line at a distance of 1 metre (Fig. 175). If the eyes look at an object half a metre distant the convergence is twice that of the unit, and convergence (C.)= 2 M.A.;

if directed toward a point one-third of a metre distant, C. = 3 M.A.; if toward an object 2 metres distant, C. = ½ M.A.

The *emmetropic eye requires* for each distance of binocular vision *as many metre angles of convergence, as it needs diopters of accommodation.* To see an object at 1 metre distance, 1 metre angle of convergence is required and also 1 diopter of accommodation; at 10 cm., 10 metre angles of convergence and 10 D. of accommodation would be required.

This *harmonious relationship between accommodation and convergence* is not, however, unchangeable. Within certain limits either of these actions may take place independently of the other.

The Range or Amplitude of Convergence.—The *far point of convergence* is the point to which the visual lines are directed when convergence is at rest; the *near point of convergence* is the point to which the visual lines are directed with the maximum amount of convergence. The distance between the far point and the near point of convergence is the *amplitude of convergence;* it is expressed by the greatest number of metre angles of convergence which the eyes are capable of exerting. In a state of rest the far point of convergence is at infinity and the visual lines are either parallel or more commonly somewhat divergent, in which case convergence is spoken of as *negative.* In some cases, the visual lines deviate inward even when convergence is relaxed; convergence is then said to be *positive.*

METHODS OF DETERMINING THE REFRACTION OF THE EYE.

There are *three principal methods* of testing the refraction of the eye: (1) the *subjective method,* in which the refraction is estimated by the acuteness of vision with test types and trial lenses; (2) *retinoscopy;* and (3) the *ophthalmoscope;* the last two are *objective* methods.

Every examination should be undertaken in a systematic manner. We begin with the *external examination* of the eyes as described in Chapter I. Next the patient is taken into the *dark room* and the *media and fundus* are examined with the ophthalmoscope (Chapter III.). Then the *refraction* is determined with the *ophthalmoscope.* The *retinoscopic mirror* is now employed to estimate the refraction with *the shadow test.* Finally, the patient is examined by the *subjective method* with test lenses and test types. By employing this order we will save time, since the ophthalmoscopic examination may show changes in the media or fundus which convince us of the impossibility of improving the patient's vision with glasses, or lead us to be satisfied with a limited result. *The objective methods* of determining the refraction of the eye give very close and accurate results; *the subjective method* serves to verify these conclusions and sometimes perfects them.

THE DETERMINATION OF THE REFRACTION BY THE ACUTENESS OF VISION WITH TEST TYPES AND LENSES. THE SUBJECTIVE METHOD.

After having determined the *acuteness of vision for distance* as described on p. 10, we endeavor to ascertain *which lenses are necessary to correct any error of refraction and to bring the vision up to the normal* $\frac{20}{20}$. The patient is placed in front of the test types, which must be well illuminated by daylight or artificial light, at a distance of 20 feet. The trial frame (Fig. 176) is worn by the patient, and the left eye excluded by means of a solid metal disc. After testing the right eye, we proceed with the left.

If the patient reads $\frac{20}{20}$, we may assume the *absence of myopia and of astigmatism;* the patient is either *emmetropic* or has *hyperopia.* A weak convex spherical lens (+ 0.50 D. Sph.) is held in front of the eye; if he is still able to read the $\frac{20}{20}$ line, he has *hyperopia*, and the *strongest*

convex spherical lens with which he can read $\frac{20}{20}$ is the measure of his *manifest hyperopia*. Even though he accepts a convex spherical lens, this is probably not the measure of his *total hyperopia*, which can be estimated in young persons only after the eye has been placed under the effects of a cycloplegic. The difference between the manifest and the total hyperopia is known as the *latent hyperopia;* it is this portion which is discovered after accommodation has been paralyzed.

If the patient reads $\frac{20}{20}$, and a weak convex spherical lens

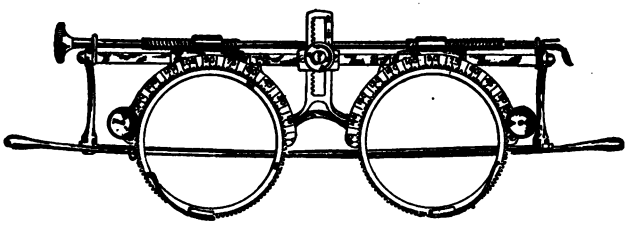


FIG. 176.—The Trial Frame.

blurs his vision, he is either *emmetropic* or has *hyperopia* which is *latent*.

If the patient's *vision is below normal*, and instead of reading $\frac{20}{20}$ he reads $\frac{20}{40}$ or $\frac{20}{70}$, he either has *considerable manifest hyperopia*, or else he is *myopic or astigmatic;* or he may have a combination of these errors. If *hyperopic*, spherical lenses will improve his vision. If such improvement does not result upon placing convex spherical lenses before the eye, we may try a weak concave spherical lens; if this aids his vision, he is *myopic*, and the *weakest concave spherical lens that brings his vision to* $\frac{20}{20}$ *is the measure of his myopia*. If concave spherical lenses do not improve the vision, we assume the existence of *astigmatism;* and *cylinders*, alone or in combination with spherical lenses, are placed in front of the eye for the purpose of estimating the kind, the axis, and the amount of astigmatism.

This is, briefly, the method pursued in determining the refraction by means of the acuteness of vision (*subjectively*); greater details will be supplied in discussing the errors of refraction. But, as already pointed out, it is better and saves time to precede this subjective test by the objective methods, using the former to confirm the findings of the others; this is especially advisable if the error of refraction be a difficult or complicated one.

The vision for near is also tested. To the patient is given a page of Jaeger's test types (Fig. 12), and we note the *smallest type* which he is able to read with *each eye separately*, the *distance* which he selects, and the *nearest and farthest distances* at which he is able to read. These data give us valuable information regarding the refraction. In *myopia*, the patient will hold the print at a *closer distance than normal*. In *presbyopia* he will hold it at a *greater distance than normal*.

THE OPHTHALMOSCOPE AS A MEANS OF DETERMINING THE REFRACTION OF THE EYE.

The Ophthalmoscope at a Distance (p. 21) gives us *qualitative information* regarding errors of refraction. When the patient is *emmetropic, no details* of the fundus will be seen when the light is thrown into the eye from an ophthalmoscope held at a distance of 15 inches. If some part of the disc or vessels is seen, the patient is *ametropic*. If the examiner moves his head from side to side and the *vessels seem to move in the same direction*, the case is one of *hyperopia* (for in hyperopia the rays emerge divergent and the image is a virtual, erect one). If the *vessels seem to move in the opposite direction*, the case is one of *myopia* (since in myopia the emerging rays are convergent and form an inverted image). If the vessels of one meridian only are seen, *astigmatism* is present; this is *hyperopic* if the vessels move *with* the movements of the observer's head,

myopic if they move in the *opposite* direction, and *mixed*, if one set move with and the other against them.

The Indirect Method is not used for determining the amount of error of refraction, but we obtain *information of the form of ametropia* by noting the size and shape of the inverted image of the disc and its behavior upon withdrawing or approaching the lens before the patient's eye. If no change takes place in the shape and size of the image when we withdraw the lens, the eye is *emmetropic*. If the shape remains the same but the image becomes *smaller* when the lens is withdrawn, it indicates *hyperopia*. If the shape remains the same but the image becomes *larger* on withdrawing the lens, the case is one of *myopia*. In *astigmatism* the disc usually appears *oval* and the shape of its image *changes* in withdrawing the lens; one diameter decreases or increases while the other remains stationary in simple astigmatism; both increase or decrease unequally in compound astigmatism; and one increases and the other decreases in mixed astigmatism.

The Direct Method is a very *valuable* means of determining the refraction, and, in case of error, the kind and the amount; reliable results are obtained, however, only after considerable practice. For accurate results, it is *necessary* that the *accommodation of both patient and observer be in abeyance*. The beginner always has difficulty in relaxing his accommodation, and requires considerable training before he masters this necessary step (p. 27). The patient's accommodation is suspended by directing him to look at the wall or at a distant object, or, better, by the use of a cycloplegic. The examiner, if ametropic, corrects his error by wearing suitable glasses, by having a special correcting lens applied to the sight-hole of the ophthalmoscope, or by subtracting the amount of his error from the result which he obtains in the examination. The examination is conducted in the manner described on p. 25; for accurate results it is essential that the *shortest* possible

distance separate the eye of the patient from that of the observer.

Emmetropia.—The examiner *selects a blood-vessel at the outer margin of the disc* or between the disc and the macula.

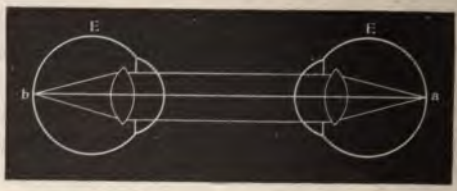


FIG. 177.—The Estimation of the Refraction by the Direct Method of Ophthalmoscopy. Both Patient and Observer are Emmetropic.

If the vessel appears distinct, and if upon rotating a + 0 50 D. lens before the sight-hole it becomes blurred, the eye is *emmetropic*. Rays coming from an emmetropic eye at rest are parallel, and the observing eye will focus these rays on the retina (Fig. 177).

Hyperopia.—If the image is *blurred*, we rotate the lens disc of the ophthalmoscope so as to place *convex lenses* in the sight-hole; if these render the image *distinct* the eye

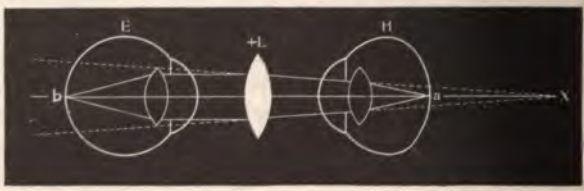


FIG. 178.—The Estimation of Hyperopia by the Direct Method of Ophthalmoscopy.

is *hyperopic*. The *strongest convex lens* with which we get a distinct image is the *measure* of the hyperopia. In Fig. 178, *H* is the hyperopic eye under examination, and *E* the emmetropic eye of the observer. Rays from *a* emerge divergent as though coming from *x*. The convex lens +

L makes them parallel so that they focus at *b*, on the retina of E, the emmetropic eye of the observer.

Myopia.—If when the image appears *blurred*, a convex lens make it more indistinct, we rotate the disc of the ophthalmoscope so that *concave lenses* are brought opposite the sight-hole. If these render the image *distinct*, the eye is *myopic*. The *weakest concave lens is the measure of the myopia*. We stop at the *weakest* concave lens which accomplishes this, since stronger lenses of this sort would only encourage the observer to accommodate. In Fig. 179, *M* is the myopic eye under examination, and *E* the emmetropic eye of the observer. Rays from *a* leave the myopic

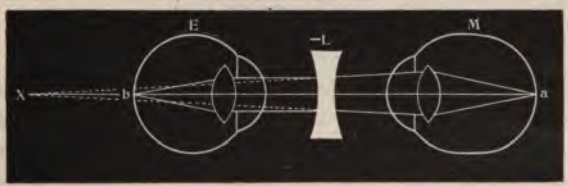


FIG. 179.—The Estimation of Myopia by the Direct Method of Ophthalmoscopy.

eye convergent and would meet at *X*. The concave lens $-L$ renders them parallel so that they are focussed at *b*, on the retina of the observer.

Astigmatism.—We find the lens with which a small *vertical vessel* is seen distinctly, and then the lens which enables a small vessel *at right angles* to be seen clearly, always remembering that the lens which clears up the image of a vessel in one direction is the measure of the refraction of the meridian at right angles to it.

Suppose the horizontal vessels appear distinct without any lens—then the vertical meridian is emmetropic; and that the vertical vessels require a convex or a concave lens to render them distinct—then the horizontal meridian is hyperopic or myopic; the case is one of *simple hyperopic or myopic astigmatism* (Figs. 196 and 197).

If both vertical and horizontal vessels are rendered distinct by convex lenses but a stronger one can be used for the horizontal, the case is one of *compound hyperopic astigmatism* (Fig. 198) with the vertical meridian the more hypermetropic; if both vertical and horizontal vessels are best seen with concave lenses but of different strength, the case is one of *compound myopic astigmatism* (Fig. 199).

If the vertical vessels can be seen clearly with a convex lens and the horizontal vessels require a concave lens, the case is one of *mixed astigmatism* (Fig 200), the horizontal meridian being hyperopic, the vertical meridian myopic.

RETINOSCOPY.

Retinoscopy, The Shadow Test, or Skiascopy, is a very *accurate and popular objective method* of estimating the refraction by *illuminating* the eye with a plane or concave *mirror,* and observing the *direction of the movement* of the retinal illumination and its bordering *shadows, when the mirror is rotated.* The shadow test has many *advantages:* It can be used in *children, illiterates,* and in *markedly defective sight;* it is entirely *objective* and hence requires no co-operation on the part of the patient; it is *easily learnt, quick,* and *accurate;* and it requires no expensive apparatus.

The principle of retinoscopy is the finding of the *point of reversal or the myopic far point.* In myopia an inverted image is formed in the air in front of the eye at the far point—the distance from which rays would be focussed on the retina; this point is known as the point of reversal. If the eye is hyperopic or emmetropic, a convex lens is placed before it so as to give it an artificial far point.

When light is thrown into the eye by means of a plane or concave mirror at a distance of one metre, the fundus is illuminated. By looking through the sight-hole of the mirror an observer will see the *illuminated portion* (red

fundus reflex) and also the *shadow* bounding this bright area On *rotating the mirror* the illuminated area and the shadow will *move across the pupil.*

The examination is conducted in the *dark room,* the darker the better. The *source of illumination is placed above the head of the patient* and somewhat behind so that his face is in darkness. An *Argand burner* is the most common form of illumination, and it is often surrounded by an asbestos chimney with a large circular opening opposite the brightest part of the flame, so that the light is thrown only toward the observer. Some oculists prefer the light placed near the observer, about 6 inches to his left and in front, with a small (10 mm.) opening in the opaque chimney.

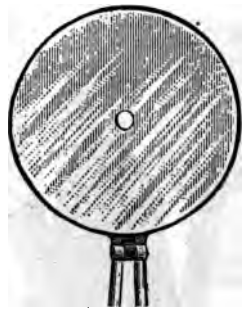


FIG. 180.—Retinoscopic Mirror.

Either a *plane or a concave mirror* may be employed; the *plane mirror* has certain advantages and is more commonly used. The retinoscopic mirror (Fig. 180) usually has a diameter of 3½ cm. with a 3 mm. opening, though sometimes a 2 cm. mirror upon a 4 cm. metal disc, with a 2 mm. opening, is preferred by those who place the light near the observer.

The patient is seated, his *pupils are dilated,* and preferably his *accommodation should be paralyzed.* He is directed to *look at the forehead of the examiner. Each eye is tested separately,* and one eye is usually covered.

The observer is seated at *one metre distance* (Fig. 181); he should *wear correcting lenses* if ametropic; he need not relax his accommodation as in using the ophthalmoscope, since this does not influence the result.

If now the mirror be rotated slowly from side to side on its vertical axis so that the light moves across the pupil

horizontally, the observer will see an *illuminated area and a shadow* coming from behind the pupil; if the mirror be rotated on its horizontal axis the light will move across the pupil vertically. *The direction of movement of this light and shadow as compared to that of the mirror depends upon the refraction of the eye.* The shadow moves either in the same (*with*) or the opposite direction (*against*) to that of the mirror; if we turn the mirror toward the right and the shadow moves toward the right, we say it moves *with* the

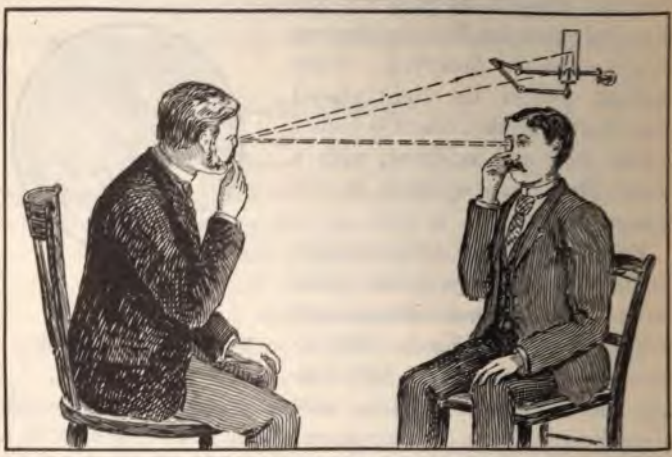


FIG. 181.—The Retinoscopic Examination.

mirror; if upon turning the mirror toward the right the shadow moves toward the left, we say it moves *against* the mirror. *With the plane mirror, the shadow moves with the mirror in hyperopia, emmetropia, and in myopia of less than* 1 *D., and against the mirror, in myopia of more than* 1 *D.*

Besides the direction of the movement, we acquire information from the *brightness*, the *form*, and the *rate of movement of the light and shadow.* If the reflex is *bright*, its edge *sharp*, and the light and shadow move *rapidly*, the

error of refraction is a *low* one; if the illumination is *dull*, its edge *indistinct*, and the movement of light and shadow *slow*, the error is a *high* one. If the shadow has a *straight edge* it is an indication of *astigmatism* (Fig. 182); in hyperopia, myopia, or emmetropia, the shadow has a *crescentic edge* (Fig. 183).

We next *find the correcting lens—i.e.*, the lens which *causes a reversal* of the direction of movement of the shadow. This lens will be correct for the distance separating the observer from the patient, *one metre*. For infinity, we must *add* -1 *D.* to all results; this increases the myopia 1 D., and diminishes hyperopia 1 D.

FIG. 182.—Retinoscopic Illumination and Shadow in Astigmatism.

FIG. 183.—Retinoscopic Illumination and Shadow in Myopia, Hyperopia, or Emmetropia.

If with the plane retinoscope the *shadow moves against* the mirror, we place *concave* spherical lenses before the eye until we succeed in causing a reversal of the movement of the shadow—*i.e.*, cause it to move with the mirror; this lens, to which we add -1 D., is the measure of the patient's *myopia*. Suppose on placing -1 D before the eye, the shadow still moves against the mirror, the same with -2 D., but with -2.50 D. the movement of the shadow is reversed; then $-2.50 + -1. = -3.50$ D. is the correction.

If with the plane retinoscope, the *shadow moves with* the mirror, the eye may be hyperopic, emmetropic, or myopic less than 1 D. In such a case we begin by adding a convex lens of $+0.50$ D. If this causes a reversal of the shadow the eye is *myopic 0.50 D.*, since $\frac{+0.50}{-1.00} = +0.50$ D. If the $+0.50$ D. lens does not alter the direction of the

movement of the shadow, but the next lens (+ 1 D.) causes a reversal, the eye is emmetropic, since $\frac{+1.00}{-1.00} = 0 = E$.

If the + 2.00 D. lens has no effect upon the direction of movement of the shadow, the eye is hyperopic; we place stronger + spherical lenses before the eye until we find the one which causes a reversal of the movement of the shadow. Say this is + 4 D.; then the hyperopia amounts to $\frac{+4}{+3} = 3$ D.

In the previous examples, the results were the same whether the mirror was rotated upon its vertical or its horizontal axis. In *astigmatism*, upon correcting each of the two principal meridians separately, one meridian will require a different lens to cause a reversal of the shadow than the other. The most common positions of the two meridians in astigmatism are *vertical* and *horizontal*. But frequently the edges of the shadows lie more or less obliquely. In such cases the mirror must be rotated so that the light moves obliquely and parallel with the movement of the shadow.

For example, suppose the shadow moves with the mirror in both meridians, but one shadow is more distinct and moves more quickly than the other; we diagnosticate astigmatism. Then we correct the vertical meridian and find it requires + 2 D. for the reversal of the shadow. Next we find that in the horizontal meridian + 4 D. is required for reversal. We add − 1 D. to each of these results and have + 1 D. vertical and + 3 D. horizontal. The case is one of compound hyperopic astigmatism and requires for its correction + 1 D. spherical lens combined with + 2 D. cylinder, axis vertical.

CHAPTER XXIII.

ERRORS OF REFRACTION.

In *emmetropia* (Em.) the eye in a state of rest, without accommodation, focusses the image of distant objects exactly upon the retina (Figs. 169, 184); such an eye enjoys *distinct vision for distant objects without effort or fatigue.* Any variation from this standard constitutes *ametropia*, a condition in which the eye, in a state of rest, is unable to focus the image of distant objects (parallel rays) upon the retina. Ametropia includes *hyperopia, myopia, and astigmatism.* The effects of ametropia are not only *indistinctness of vision* but various pains and other symptoms comprised under the term *asthenopia* (*weak sight, eye strain*).

HYPEROPIA, HYPERMETROPIA, OR FARSIGHTEDNESS.

Hyperopia (H.) is an error of refraction in which, with accommodation completely relaxed, *parallel rays* (rays from distant objects) are brought to a *focus behind the retina* (Figs. 170, 184); divergent rays (from near objects) are focussed still farther back.

Etiology.—It is most commonly due to *shortening of the antero-posterior diameter* of the eyeball (*axial H.*), less frequently to diminished convexity of the refracting surfaces of the eye (*H. of curvature*), changes in the media, or absence of the lens (*aphakia*). It is by far the *most frequent error* of refraction and may be looked upon as *congenital*, being usually considered as due to a lack of development of

the eye. It is often *hereditary*. Children are usually *hyperopic at birth* and subsequently become less hyperopic, emmetropic, or even myopic.

The Course of Rays.—The hyperopic eye cannot, without accommodation, see either distant or near objects distinctly (Fig. 184). In a condition of rest, it is adapted for convergent rays and these are not found in nature. *To focus parallel rays* on the retina it must either *accommodate, i.e., increase the convexity of its lens* as shown in Fig. 185, or a *convex lens* of such a strength that the rays are made *sufficiently convergent* to be brought to a focus on the retina (Fig. 186) must be placed in front of the eye.

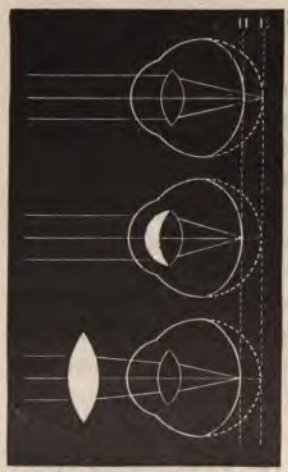


FIG. 184.—Hyperopic Eye in a State of Rest.

FIG. 185.—Hyperopic Eye during Accommodation.

FIG. 186.—Hyperopia Corrected by a Convex Lens.

To focus divergent rays, i.e., rays from near objects, the hyperope must not only *accommodate* the amount required of an emmetropic eye (Fig. 187), but an *additional amount* to compensate for his error. In other words, he requires some accommodation constantly in order to see distant objects distinctly, and in addition the amount equal to that required by the emmetrope for near vision (Fig. 188). Such an eye (when the error is uncorrected) is *never in a condition of rest* as long as it enjoys distinct vision.

Changes in the Eye.—As a result of the constant strain and overaction of the *ciliary muscle*, the latter becomes *hypertrophied*, especially its circular fibres (Fig. 190); it remains in a greater or lesser condition of spasm. In *high*

degrees of H. the *eyeball* may be *diminished in size*, the anterior chamber shallow, the sclera flat with a sharp curve at the equator, and there may be an apparent external squint.

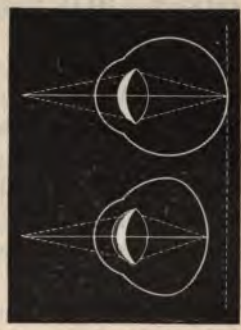


FIG. 187.—Emmetropic Eye Accommodating for Near Vision.

FIG. 188.—Hyperopic Eye Accommodating for Near Vision.

Varieties.—Hyperopia is divided into (1) *manifest*, (2) *latent*, and (3) *total*.

The manifest hyperopia (Hm.) is that which is detected *without paralyzing the accommodation* and is represented by the strongest convex glass with which the patient sees most distinctly; it corresponds to the amount of accommodation which he relaxes when a convex lens is placed before the eye.

The total hyperopia (Ht.) is the *entire amount* of hyperopia detected *after the accommodation has been paralyzed* or during complete relaxation of the ciliary muscle.

The latent hyperopia (Hl.) is the difference between the Hm. and the Ht., and is the *amount which is habitually concealed* and is discovered only after the use of a cycloplegic.

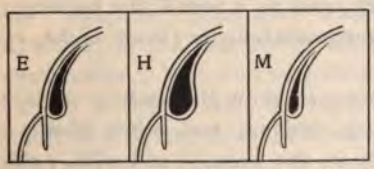


FIG. 189. FIG. 190. FIG. 191.

FIG. 189.—Section of the Ciliary Muscle in an Emmetropic Eye.

FIG. 190.—Section of the Ciliary Muscle in a Hyperopic Eye.

FIG. 191.—Section of the Ciliary Muscle in a Myopic Eye.

The application of these terms can be illustrated by considering an example of H. of 2.5 D. in a young person. If in such a case V = $\frac{2}{4}\frac{0}{0}$ and, without the use of a mydriatic, a + 1 D. spherical lens brings up the vision to $\frac{2}{2}\frac{0}{0}$, we say Hm. = 1 D.; if now we paralyze the accommodation with a cyclo-

plegic and find $V = \frac{20}{100}$, and that a + 2.50 D. spherical lens increases this to $\frac{20}{20}$, the Ht. = 2.50 D.; the difference between 2.50 D. and 1.00 D. = 1.50 D. = Hl.

The *ratio* between the manifest and the latent hyperopia is *not constant;* it *depends* more or less upon the *age and vigor* of the individual. In *youth*, the amount of Hl. is apt to be considerable, and consequently a cycloplegic is essential in estimating the amount of hyperopia. The *older* a person grows, the less accommodative effort he is able to make; hence the Hl. becomes less, and the Hm. greater.

In *old persons*, there is no Hl., the total hyperopia becoming manifest.

Symptoms.—Unless the error be considerable or the patient be advanced in years, there is *usually distinct vision for distance.* A great many patients with hyperopia present *no symptoms* whatever; this is apt to be the case when the hyperope is *young*, in *good health*, and indulges in plenty of *out-door exercise.* Under these circumstances he is apt to accommodate for his optical defect without any evidence of overaction of the ciliary muscle. In *other cases*, the accommodative efforts will be unequal to the task imposed in near work, and as a result the hyperopia will give rise to *accommodative asthenopia* (*weak sight, eye strain*).

The Symptoms of Asthenopia show themselves particularly after reading, writing, sewing, and other forms of *near application*, especially in the *evening* and with *artificial illumination.* They comprise *pain* referred to the eyes or above the eyes; *headaches*, usually frontal, but also occurring in the occiput and other parts of the cranium; various *neuralgias; congestion* of the conjunctiva and margins of the lids; *lachrymation*, blinking, and slight photophobia; *burning sensation* in the lids; and *blurring of near vision.* These symptoms are more pronounced whenever the general health is below par.

With advancing years, there will be greater difficulty in

reading without correcting glasses; *presbyopia occurs earlier* than in emmetropia in proportion to the degree of H.

In *early childhood*, hyperopia often causes *convergent squint*. The great effort necessary for accommodation causes excessive contraction of the internal recti muscles; to avoid this discomfort, one eye is turned in (p. 356).

In *children*, H. shows a *physiological tendency to diminish* with the growth of the child; after puberty it may become greater. In the adult it remains stationary, and after fifty there is a tendency to a slight increase.

Hyperopic eyes are predisposed to conjunctivitis and blepharitis, phlyctenular affections, internal squint, and glaucoma.

Tests.—These have been described in the preceding chapter. They are the following:

1. *The Subjective Test with Test Types and Test Lenses.*—We first record the acuteness of vision and then place convex lenses before the eye, commencing with + 0.50 D. The *strongest lens* with which the patient sees $\frac{20}{20}$ or better is the measure of the *manifest hyperopia*. Then the *accommodation* is *paralyzed* and the test repeated; the strongest lens "*accepted*" (*i.e.*, with which the patient's vision is improved) is the measure of his *total hyperopia*. Such an examination is recorded as follows:

O. D. V = $\frac{20}{20}$; Hm. 0.50 D.; Hom. V = $\frac{20}{100}$; $\frac{20}{20}$ w. + 2 D. S. Translated, this line would read: Oculus dexter (right eye), vision equals $\frac{20}{20}$; manifest hyperopia 0.50 D.; after the use of homatropine, vision equals $\frac{20}{100}$, increased to $\frac{20}{20}$ with a convex spherical lens of 2 diopters.

The Ophthalmoscope at a Distance.—The retinal vessels appear to move in the same direction as the observer's head.

The Ophthalmoscope, Indirect Method.—On withdrawing the lens in front of the patient's eye, the size of the disc diminishes.

The Ophthalmoscope, Direct Method.—The disc and ves-

sels can be seen distinctly with a convex lens in the sight-hole, the strongest being the measure of the H.

Retinoscopy.—With the plane mirror held at one metre, the shadow moves with the mirror; the direction of movement is reversed by convex lenses placed in front of the patient's eye. The lens which causes a reversal, minus 1 D., is the measure of the H.

Treatment consists in prescribing such *convex spherical lenses* as will make *vision distinct* and enable the patient to do near work *without fatigue*. The mere existence of hyperopia is no indication for the use of correcting glasses unless these are worn in childhood for the cure of convergent squint. It is only when there is a diminution in the acuteness of vision or when symptoms arise indicating eye strain that convex lenses should be used.

Though theoretically it would seem proper to prescribe the full correction (for Ht.), practically there are many objections and exceptions to this. In *every case* of hyperopia occurring in *children and in young adults, the accommodation should be paralyzed and the total error estimated* so as to serve a basis for the prescription for glasses. There is considerable difference of opinion among oculists as to *the proportion of the Ht. which ought to be corrected*, and the constancy with which the glasses should be worn.

The symptoms of the individual give us reliable indications on these points. In cases of squint, and when glasses are prescribed for the relief of conjunctivitis, blepharitis, and headaches which are continuous, or the occurrence of which is independent of near use of the eyes, they must be worn constantly. In other cases, glasses should be worn continuously or only for near, according to whether the symptoms are always present or follow only after using the eyes for reading and the like. When distant vision is perfect and comfortable, and the patient does not suffer from any symptoms except when engaged in near work, *glasses* need be prescribed only for such use; this is often

the case in young people who enjoy good health. Under such circumstances, the correction of the Hm. may be sufficient; or we may add to this the correction for part of the Hl., or we may correct the Ht. In cases in which the correction is only partial, the glasses must frequently be changed from year to year. In hyperopes after forty-five, convex lenses should be worn to improve distant vision, and a stronger pair for near; the weaker set is for the H., the stronger pair to correct both the hyperopia and the presbyopia. Under such circumstances, *bifocal lenses* (Fig. 207) are very convenient, the upper segment corresponding to the weaker glass, the lower to the stronger.

MYOPIA, NEARSIGHTEDNESS, OR SHORTSIGHTEDNESS.

Myopia (M.) is that refractive condition in which, with accommodation completely relaxed, *parallel rays are brought to a focus in front of the retina.* These rays cross in the vitreous; when they reach the retina they have become divergent, forming a circle of diffusion and consequently a blurred image (Fig. 192, *PPF*). Certain divergent rays, coming from the myopic far point, are focussed on the retina (Fig. 192, *DX*) without accommodation.

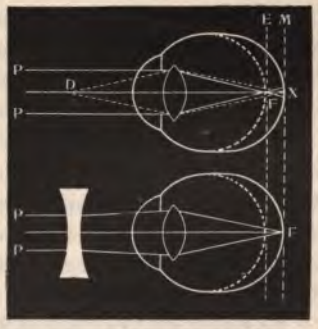


FIG. 192.—The Focussing of Parallel and Divergent Rays in Myopia.

FIG. 193.—The Correction of Myopia by means of a Concave Lens.

The greatest distance at which the patient can read the smallest print is the *far point.* This is always at a *definite distance corresponding to the amount of M.;* the higher the M., the closer to the eye is the far point; the distance of the latter is the *measure of the M.* For example, if the far point is at

20 inches (.5 metre or 50 cm.) the M. = 2 D. ($\frac{4}{20}$ or $\frac{10}{50}$ = $\frac{2}{5}$); if at 10 inches (.25 metre) the M. = 4 D. In these two instances concave lenses of 2 and 4 D. respectively would render parallel rays as divergent as if they came from a distance of 20 and 10 inches (.5 and .25 metre); and with these lenses, the myope would be able to see distant objects distinctly (Fig. 193).

Etiology.—Myopia almost always depends upon a *lengthening of the antero-posterior diameter* of the eyeball (*axial myopia*); in M. of 3 D., for example, the eyeball measures 24 mm. in its antero-posterior diameter, and in M. of 10 D., 25 mm. from before backward, instead of 23 mm., the normal diameter. Much less frequently M. is due to increased curvature of the cornea (anterior staphyloma and keratoconus), increase in the refraction of the lens from swelling in incipient senile cataract (often referred to by the laity as "*second sight*"), and spasm of accommodation. *The determining causes* are associated with the demands which *civilization and education* make upon near vision. It is rarely congenital, though there is often an *hereditary tendency* for its development. It is an *acquired* change which commences at an early age when, during the developing period, the *eyes are used excessively or improperly for near work*. Its occurrence is in direct proportion to the standard of education, and also bears a certain relation to the general health and strength of the individual. It is much more common in cities than in the country. It increases in percentage from the lower to the higher classes in schools and universities.

Excessive study with insufficient out-door exercise, fine or *indistinct print, poor illumination*, opacities of the cornea and other lesions causing imperfect vision, faulty construction of desks, sedentary habits, and poor health are among the frequent exciting causes of myopia, especially in those who are predisposed.

The cause of the lengthening of the eyeball is attributed

(1) to pressure of the extraocular muscles during excessive convergence causing the posterior pole, which is the least resistant part of the eyeball, to bulge; (2) to congestion, inflammation, and softening of the layers of the eyeball, together with increased tension, produced by fulness of the veins of the head as a result of stooping postures and other predisposing causes; and (3) to the shape of the orbit in broad faces causing excessive convergence, as seen in the German race, which is especially subject to this error of refraction.

Clinical Forms.—In most instances, myopia is of low degree, develops during youth, and then comes to a stand-still or increases very little; this is known as *stationary or simple myopia.*

In other cases, the error reaches a considerable height in youth, and *increases* steadily up to the twenty-fifth year or even later, resulting in a *high degree* of myopia; this is known as *progressive myopia.* These are the cases which are accompanied by *destructive changes* in the chorioid and other parts of the eye, leading to a considerable impairment of vision, and even blindness, and in which myopia may properly be considered *a disease.* Extreme cases of progressive myopia are known as *malignant myopia.*

Symptoms depend on the degree of myopia.

In slight degrees and in many cases of moderate amount, there are often no symptoms except *indistinct vision* for distance. Near work can be accomplished with comfort; in fact, since the myope requires less accommodation than the emmetrope, he may have an advantage in close application. It is on this account that the circular fibres of the ciliary muscle are less developed than in the emmetropic eye (Fig. 191).

In other cases of moderate myopia and in *high degrees, distant vision is very indistinct;* there is often *pain* in the eyes after near use; the patient will be unable to continue at work for any length of time on account of excessive

convergence; the eyes *tire easily*, are sensitive to light, and *irritable*; there are black spots before the eyes (*muscæ volitantes*), and sometimes bright flashes of light. In some cases there may be absolute scotomata.

In high myopia, there are often prominence of the eyes, a deep anterior chamber, and dilated pupils; the patient is apt to screw the eyelids together; there is sometimes an appearance of convergence. The strain of excessive convergence is so great and painful, that the effort is sometimes given up and divergent squint results.

Ophthalmoscopic Signs.—*In low* (less than 3 D.) *or moderate* (3 to 6 D.) degrees, there are frequently no changes except a *crescent-shaped patch of atrophy of the chorioid* of whitish or grayish color, embracing the outer side of the disc; this is called a *myopic crescent.*

In high myopia (more than 6 D.), a well-marked *crescent* is usually found, often *posterior staphyloma* (bulging of the sclera, Fig. 91, Plate III.), and there may be patches of *chorioidal atrophy* with pigmented margins, exposing the sclera. In *progressive cases*, there are frequently added to these lesions atrophic and pigment *changes in the macular region, hemorrhages*, especially at the yellow spot, *fluid vitreous* (causing tremulous iris), *floating bodies* in the vitreous, and opacities of the lens; sometimes there is detachment of the retina. Owing to these changes, the *vision* is often very markedly *reduced* and is sometimes *lost* in severe forms of progressive myopia.

Prognosis.—In low and moderate degrees of *stationary myopia*, the prognosis is *good* when suitable glasses are worn. *Progressive myopia* is always a *serious* condition, especially when the chorioidal and vitreous changes are marked; it frequently necessitates absolute cessation of all near work. In *malignant myopia* the prognosis is *grave.*

Tests.—*The Subjective Test with Test Types and Test Lenses.* Distant vision is below the normal and the patient requires a *concave spherical lens* to bring the sight up

to $\frac{20}{20}$. The *weakest lens* which accomplishes this is the measure of the myopia. In young persons it is important to *paralyze the ciliary muscle*, so that spasm of accommodation will not cause the patient to select too strong a lens. The results are recorded as follows: O.D. V = $\frac{20}{200}$; $\frac{20}{20}$ w. — 4 D. Sph. The reduction in distant vision generally corresponds to the amount of M.

The myope is able to read the smallest print, but at a shorter distance than that which the emmetrope selects. The farthest distance at which he is able to read the finest print is his *far point*, and this is also a *measure of his M.* (p. 309).

The Ophthalmoscope at a Distance shows an inverted image of the fundus which appears to move in the opposite direction to the examiner's head.

The Ophthalmoscope, Indirect Method.—The disc appears small and seems to increase in size upon withdrawing the objective lens.

The Ophthalmoscope, Direct Method.—The fundus cannot be distinctly seen until a concave lens is placed behind the mirror; the weakest concave lens with which the details are seen clearly, indicates the amount of myopia.

Retinoscopy.—With the plane mirror and the observer at 1 metre distance, the shadow moves in the opposite direction (except when M. is less than 1 D.), and is reversed by the addition of concave lenses. The lens which causes reversal plus —1 D. is the measure of the M. In high M. the shadow is very faint, but becomes plainer when concave lenses are added.

Treatment consists in prescribing *suitable glasses, limiting the amount of work* so that there will be no fatigue, and *preventing the progress* of the disease.

In general terms, it is proper to give a *full correction for low and moderate myopia in young persons*, as soon as discovered, and to direct these glasses to be worn for *both distance and near;* this places the eyes under normal con-

ditions of vision and accommodation. The glasses must be prescribed after the accommodation has been paralyzed, so that there will be no danger of over-correction on account of spasm of accommodation. Full correction corresponds to the *weakest concave spherical lens* which, with accommodation paralyzed, gives normal vision. In low degrees of M. the patient may be allowed to read without glasses if he finds this convenient.

In *high myopia*, the full correction is prescribed for distance, and about two-thirds correction for near work; the reading-glasses should be such as to enable the patient to read at a comfortable distance, say 13 inches (33 cm.). Suppose −10 D. gives the best vision for distance; then −10 D. +3 D. Sph. = −7 D. will enable him to read at this distance without accommodation.

After the age of 45, the distance glasses cannot be worn for near work, since the convex lenses usually required for presbyopia must be added to the concave lenses, thus reducing the strength of the latter.

The prescribing of glasses in M. is often a matter *requiring great experience;* every case must be considered on its merits. Many myopes wear strong lenses, representing the full correction, constantly and with absolute comfort; others require two sets of lenses, one for distance and a weaker pair for reading.

In order to check any tendency to increase of M., *rigid hygienic rules*, both local and general, should be carried out. These are of especial importance in the young.

The patient's *habits should be regulated* so that he will enjoy good health. He should have an abundance of *outdoor exercise and plenty of sleep.*

Near work should be restricted and the patient not be allowed to read too long at a time. The *book* should be held at 13 inches (33 cm.). In most cases the full *correcting lenses* should be worn for near work. The *illumination* should be good, neither too bright nor too dim, and should

come from behind; the myope should avoid reading at dusk or with feeble illumination; the amount of work done with artificial light should be limited. The *print* should be large and clear, with ample spacing. *Desks* should be constructed so that the sitting posture is comfortable, and so that the child is not encouraged to stoop over his books; the myope must be taught not to bend over his work, but to lift the latter to the required distance from the eyes.

If notwithstanding such precautions, myopia progresses, it is necessary to forbid all near use of the eyes. A good plan is to take the patient from school and send him to the country for a long period, during which he is instructed to be out-of-doors as much as possible, and to avoid all reading and near work. Young adults suffering from progressive myopia should *give up sedentary occupations* necessitating close application, and select those in which but little near use of the eyes is required.

Operative Treatment.—In children and young adults with *high myopia*, uncomplicated by excessive pathological changes in the fundus, *the removal of the lens* by discission and subsequent extraction is frequently very successful. The lens is *needled*, and after several days the swollen lens substance is removed by *extraction*. The operation is limited to *M. of 15 D. or more.* After the removal of the lens the eye is almost emmetropic, a weak convex glass being required for distance, and a stronger one for near work since the accommodation has been sacrificed. The operation does not seem to increase or decrease the danger of complications. It has not been performed very frequently in America, but in Germany, where M. is very common, it is practised quite often.

ASTIGMATISM.

Astigmatism (As.) is that refractive condition of the eye in which there is a *difference in the degree of refraction* in different meridians; each of the principal meridians has, therefore, a different focus (Figs. 196–200).

In E., H., and M., rays coming from a luminous point are brought to a single focus at a certain distance behind the cornea. In astigmatism, since the refractive surfaces are not spherical, rays from a luminous point are brought to a focus at different points.

Varieties.—Astigmatism may be divided into (1) *Irregular*, comparatively infrequent, and (2) *Regular*, very common.

Irregular Astigmatism consists in a difference of refraction in different parts of the same meridian. It is generally due to *changes in the cornea*, such as opacities and cicatrices following ulceration, injuries, or surgical operations, and keratoconus. It may also result from partial dislocation of the lens, or from a congenital or acquired change in the refractive power of different sectors of the lens. *The acuteness of vision* is considerably *diminished and cannot be improved materially by glasses.* Details of the *fundus* when seen with the ophthalmoscope appear *distorted.* An insignificant amount of irregular astigmatism is present normally, and accounts for our seeing the stars as stellate points instead of round dots.

REGULAR ASTIGMATISM.

Regular astigmatism is that form in which, though the refraction in a meridian is the same throughout, there is a *difference in the degree of refraction of the two principal meridians.* In other words, the curvature of the cornea is different in the two meridians; these are called the *principal meridians* and are *always at right angles to each other;*

one exhibits the *maximum* and the other the *minimum* refraction. When the term astigmatism is used without qualification, it refers to regular astigmatism.

Etiology.—Astigmatism is usually due to a *change in the curvature of the cornea*, with or without some shortening or lengthening of the antero-posterior diameter of the eyeball. It is also caused, in part at least, by defects in the curvature of the lens; this lenticular astigmatism may partly neutralize that of the cornea. It is usually *congenital* and there is often an *hereditary* tendency. It may, however, be *acquired*, and is then caused by corneal changes resulting from inflammation, injury, or operation. Pressure of the lids in ametropia is sometimes considered a factor in acquired regular astigmatism.

Even the normal eye has a slight amount of regular astigmatism, due to the fact that the cornea is the segment, not of a sphere, but of an ellipsoid; consequently there is a slight difference in the refraction of the two principal meridians, the curvature of the vertical meridian being greater than that of the horizontal; hence the focus of the former is shorter than that of the latter. This can be demonstrated by looking at a vertical and a horizontal line crossing each other on a card; the horizontal line will be seen clearly at a much shorter distance than the vertical, since it is best perceived by the vertical meridian.

Refraction of Rays in Regular Astigmatism.—Parallel rays refracted by a spherical surface form a circular cone and come to a focus at a point. In astigmatism, those rays which pass through the meridian of greater curvature come to a focus sooner than those which pass through the meridian of lesser curvature, and the resulting cone will not be circular, but more or less oval; hence the vision of astigmatic subjects is not simply indistinct, but the diffusion images are more or less elongated.

In looking at straight lines (which are made up of a succession of points), these may appear distinct or indistinct to

astigmatic persons according to their direction. If an astigmatic eye, in which the vertical meridian is out of focus and the horizontal meridian normal, looks at a vertical line, this will be slightly elongated; but the sides will appear distinct, since each point of light will be seen as a small vertical line, and these overlap each other. But if such an eye looks at a horizontal line, each point of light will again be seen as a small vertical line, and consequently the line will appear blurred (Fig. 194). There is, therefore, one direction in which straight lines appear most distinct, and another at right angles to it, in which they appear most indistinct; this forms the basis for the construction of the *astigmatic dial* or fan (Fig. 201) commonly used as a test for this error. *The lines parallel with the ametropic meridian are seen most*

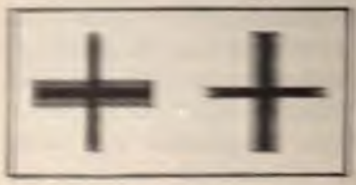


FIG. 194. FIG. 195.

FIG. 194.—Vertical and Horizontal Lines as Seen by an Astigmatic Eye in which the Horizontal Meridian is Emmetropic.

FIG. 195.—Vertical and Horizontal Lines as Seen by an Astigmatic Eye in which the Vertical Meridian is Emmetropic.

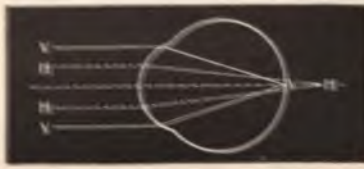


FIG. 196.—Simple Hyperopic Astigmatism.

FIG. 197.—Simple Myopic Astigmatism.

clearly, and those parallel with the emmetropic meridian are seen most indistinctly (in simple As.).

Varieties of Regular Astigmatism.—According to the refraction of the principal meridians, astigmatism is divided into:

1. *Simple*, in which one meridian is emmetropic and the other hyperopic or myopic; it comprises simple hyperopic astigmatism (H. As.) (Fig. 196), and simple myopic astigmatism (M. As.) (Fig. 197).

2. *Compound*, in which both meridians are either hyperopic or myopic, but unequal in degree; it comprises com-

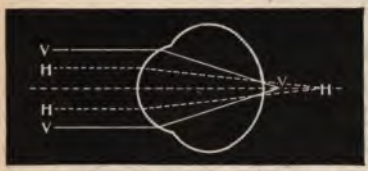


FIG. 198.—Compound Hyperopic Astigmatism.

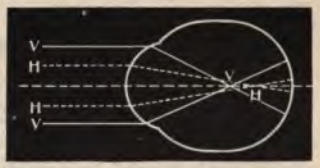


FIG. 199.—Compound Myopic Astigmatism.

pound hyperopic astigmatism (Comp. H. As., or H. H. As.) (Fig. 198), and compound myopic astigmatism (Comp. M. As. or M. M. As.) (Fig. 199).

3. *Mixed*, in which one meridian is hyperopic and the other myopic (Fig. 200).

In most cases of astigmatism, the cornea presents its *maximum curvature in or near the vertical meridian* and the least curvature in or near the horizontal meridian, corresponding to the astigmatism of the normal eye; when this is the case, it is said to be *astigmatism with the rule;* when the relative curvatures are reversed, it is *astigmatism against the rule.* In astigmatism with the rule the axis of the cylinder is vertical or nearly so in hyperopic astigmatism, and horizontal or nearly so in myopic astigmatism. The chief meridians, though *vertical and horizontal* in the majority of cases, may occupy an *oblique* position; in such cases they

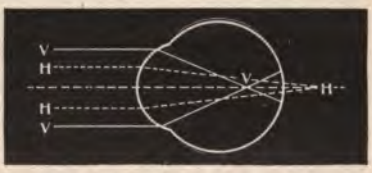


FIG. 200.—Mixed Astigmatism.

are most frequently *symmetrical, i.e.*, inclined an equal number of degrees from the vertical or horizontal on each side.

The Correction of Astigmatism.—Astigmatism is corrected by cylinders, sphero-cylinders, or crossed cylinders (p. 281). The curve of the correcting cylinder corresponds to the ametropic meridian; consequently its axis is at right angles to this meridian.

Symptoms.—There is always a *diminution in the acuteness of vision* both distant and near, the amount depending upon the degree and variety of astigmatism; it is least with simple astigmatism, more with compound astigmatism, most with mixed astigmatism. There is commonly *considerable asthenopia*, especially upon use of the eyes for near work. These asthenopic symptoms are similar to those occurring in hyperopia (p. 306), but are apt to be more pronounced and more continuous. They vary with the degree and variety of astigmatism, the amount of near work indulged in, and especially the *state of the patient's health*; a small amount (0.50 D. or even 0.25 D.) will, for instance, often give rise to severe asthenopic and nervous symptoms in a young, delicate, neurasthenic individual. The involuntary accommodative efforts of the ciliary muscle, made to diminish the effects of the error, cause continuous *eye strain* and explain the frequency of *asthenopia*.

Tests.—We usually *suspect astigmatism* when the vision cannot be brought up to $\frac{20}{20}$ with spherical lenses, notwithstanding the fact that the fundus is normal and the media are clear. In testing for astigmatism in children and in young adults, and sometimes even in adults of forty, it is necessary to have the eye under the influence of a *cycloplegic*; otherwise the results are apt to be unsatisfactory.

The Astigmatic Dial.—The diagnosis of astigmatism is made if the patient when placed before the astigmatic dial or fan (formed of radiating lines numbered like the face of a clock, Fig. 201), is unable to see all the lines with equal

distinctness. The line seen most distinctly and the line seen least distinctly indicate the axes of the two principal meridians; the axis of the former corresponds to the ametropic meridian, that of the latter to the emmetropic meridian (in simple astigmatism).

Suppose in an example of simple astigmatism, the patient sees lines *XII* and *VI* most distinctly and those at right angles, *IX* and *III*, least clearly; then the ametropic meridian is vertical. If we place a weak convex lens in front of the eye, and find that this makes lines *XII* and *VI* indistinct, we know that the horizontal meridian is emmetropic. Next we find which spherical lens clears up lines *IX* and *III;* this glass is the measure of the refraction of the vertical (ametropic) meridian.

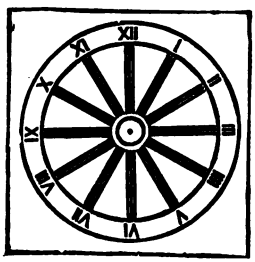


FIG. 201.—Astigmatic Dial.

The Metal Disc with Stenopœic Slit (about 1 mm. in diameter) may be used to discover the *two principal meridians.* It is placed in front of one eye, the other being excluded, and is rotated slowly so that the slit occupies each meridian successively. The patient is placed at 20 feet before the distant test types and the position of the slit in which the best vision is obtained is noted. Then convex or concave lenses are placed in front of the slit, and the strongest convex or the weakest concave lens which gives the most improvement is the measure of the refraction in this meridian. The slit is then turned 90°, and convex and concave lenses are again applied until one is found which improves vision most. In this way the refraction of the two principal meridians is obtained. If, for instance, when the slit is vertical the patient reads $\frac{2}{20}$, and convex lenses in front of the slit make the types indistinct, the vertical meridian is emmetropic; if, when the slit is horizontal, the patient

reads $\frac{8}{5}\frac{0}{0}$, but this increases to $\frac{8}{8}\frac{0}{0}$ when +3 D. Sph. is placed in front, the horizontal meridian is hyperopic 3 D.; this case would be one of simple hyperopic astigmatism corrected by a +3 D. cylinder, axis vertical.

The Subjective Test with Test Types and Test Lenses is best employed after the objective tests have furnished us with pretty definite conclusions regarding the correcting lenses. It then serves to confirm or improve upon the results obtained by objective methods.

The Ophthalmoscope, Indirect Method.—The shape of the disc is *oval* instead of circular, and changes when the objective lens is withdrawn.

The Ophthalmoscope, Direct Method.—The disc appears oval, the elongation corresponding to the meridian of greatest refraction, and is at right angles to the long axis of the oval seen with the indirect method. To determine the kind and amount of error we estimate the refraction of a small vertical vessel and then of a small horizontal vessel near the disc, by means of the strongest convex or the weakest concave lens with which these are distinctly seen. For instance, suppose a vertical vessel is seen clearly with +2 D. Sph. (indicating hyperopia of horizontal meridian), and a horizontal vessel with +4 D. (indicating a greater amount of hyperopia in the vertical meridian); the case is one of compound hyperopic astigmatism. When the principal meridians are oblique, we find a vessel the direction of which corresponds to one of the meridians, and then another at right angles to the first, and estimate the refraction of each.

Retinoscopy is the most rapid and reliable objective method of determining astigmatism. The principal meridians are clearly indicated by the edge of the shadow (Fig. 182). Each of the principal meridians is corrected separately by causing a reversal of the movement of the shadow by spherical lenses, and adding −1 D. (with plane mirror at 1 metre distance).

The Ophthalmometer (Fig. 202) is an instrument used for determining the principal meridians and the amount of *corneal astigmatism*. It is of service when used in connection with other tests. It consists of a telescope containing a combination of convex lenses and a bi-refracting prism, supporting a graduated arc upon which are two sliding objects called "mires." The latter are of white enamel, one

FIG. 202.—The Javal-Schiötz Ophthalmometer.

quadrilateral in shape, the other of similar size but cut out on one side into steps; both are divided in the middle by a horizontal black line. The patient's face is placed in a frame at the other end of the instrument and steadied by chin and forehead rests. The mires are reflected upon the cornea, and the observer, looking through the tube and focussing, sees four images in a line. The two peripheral images are ignored; the two central ones are approximated

until their inner edges touch and the black lines subdividing the mires form one continuous straight line; it may be necessary to revolve the barrel of the telescope more or less of 45° to the right or left to accomplish this. This position, indicated on a dial, gives the meridian of least refraction. Next the arc is turned at right angles to this meridian. If the images of the mires are still in apposition, the curvature of the cornea is uniform and there is no corneal astigmatism (Fig. 203). If in the second meridian the relative position of the images of the mires has changed, each step which is overlapped by the quadrilateral figure indicates 1 D. of astigmatism (Fig. 204).

FIG. 203.

FIG. 204.

FIG. 203.—The Mires of the Ophthalmometer Indicating an Absence of Corneal Astigmatism.

FIG. 204.—The Overlapping of the Mires of the Ophthalmometer Indicating 1 D. of Corneal Astigmatism.

Placido's disc or keratoscope (Fig. 4) consists of a circular disc upon which are painted alternate rings of black and white. The patient is placed with his back to the light and fixes the centre of the disc, while the examiner looks through an opening in the centre and sees an image of the concentric circles reflected upon the patient's cornea. If no astigmatism is present the rings are circular. If regular astigmatism exists, the rings will appear elliptical with the long axis corresponding to the meridian of least curvature. If the cornea is the seat of irregular astigmatism the rings will be distorted. This forms a very useful qualitative test.

Treatment consists in prescribing *glasses which correct the error*. In many cases of moderate or high degree it is impossible to obtain V. $\frac{20}{20}$ with the full correction; we often have to be satisfied with $\frac{20}{30}$ or $\frac{20}{40}$. But the vision often improves after the lenses have been worn for a time. *The glasses should be worn constantly*. When the correction

has been estimated with the eye under the effects of a cycloplegic, a slight reduction must be made in cases of moderate or high degrees of astigmatism; after a while, the

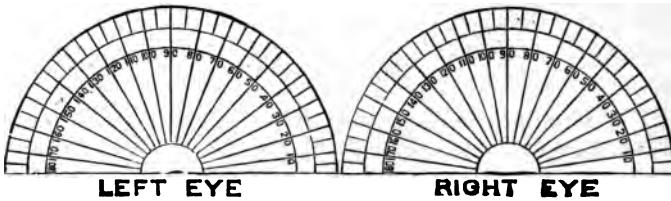


FIG. 205.—Notation of the Axis of Cylinders.

full correction will be tolerated. The relief which cylinders give is usually very pronounced.

The Direction of the Axis of a Cylinder is indicated according to two systems:

(1) By the angle which the axis makes with the horizontal, the angles being numbered from 0° on our right side (as we stand before the patient) to 180° on our left side (Fig. 205), *i.e.*, commencing at the nasal side of the

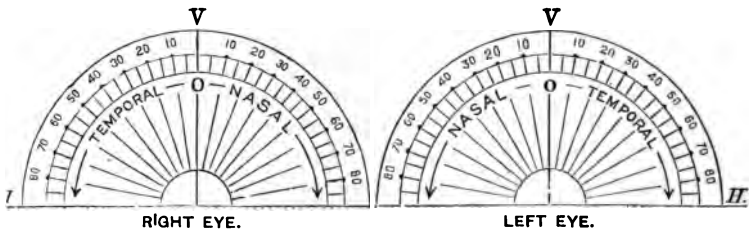


FIG. 206.—Notation of the Axis of Cylinders.

right eye and the temporal side of the left eye of the patient.

(2) The position of the axis is denoted by the angular deviation of the upper end of the cylinder from the vertical meridian, either on the nasal or the temporal side. The vertical meridian is indicated by *V*, the horizontal meridian

by *H*, the angles on the temporal side by *t*, and those on the nasal side by *n*. Thus, $30n = 30°$ toward the nasal side; $60t = 60°$ toward the temporal side, from the vertical meridian (Fig. 206).

ANISOMETROPIA.

This term is applied to cases of *marked inequality in the refraction of the two eyes;* slight differences are present in most cases of errors of refraction. Every possible combination may occur: (1) One eye may be emmetropic and the other ametropic; (2) both eyes may have the same variety of ametropia, but of unequal degree; (3) one eye may be myopic and the other hyperopic, either simple or combined with astigmatism. Notwithstanding the unequal refraction, there is often binocular vision; sometimes the eyes are used alternately; and in other cases one eye is habitually excluded from vision.

In prescribing glasses considerable judgment must be exercised, and *no arbitrary rules can be followed;* each case must be considered by itself. When one eye is emmetropic and the other ametropic, no glass will probably be required, unless it be to prevent the ametropic eye from suffering from disuse. When the difference in the refraction is not great (1 to 2 D.) and there is good binocular vision, we may give each eye its correction. When the difference is greater, the patient is often unable to stand the full correction, since it causes discomfort; then we must be satisfied with a partial correction. When there is no binocular vision, we generally give a correcting glass for the better eye. In such cases, if the poor eye still possesses vision, the patient should be advised to exercise it daily with the aid of a suitable lens, the good eye being occluded, so that the amblyopic eye may retain its vision and the latter prevented from becoming worse.

ASTHENOPIA.

Asthenopia, *weak sight or eye strain*, is a convenient term which embraces the group of symptoms dependent upon *fatigue of the ciliary muscle or of the extraocular muscles.*

Symptoms.—The condition is of *very frequent* occurrence and causes a *great variety of symptoms.* The most common manifestations of asthenopia are: (1) *Pain* in or around the eyes or *headache*, usually aggravated by use of the eyes for close work, and in some cases present only after near use. (2) *Fatigue and discomfort* upon use of the eyes for near; this shows itself by inability to indulge in such work for more than a short period at a time, without the occurrence of dimness of vision and confusion of the lines of print, pain in and about the eyes, headache, lachrymation, photophobia and congestion, and an irritable condition of the lids accompanied by itching and burning sensations. These symptoms are regularly *worse at night*, when the patient is *tired*, or when *artificial illumination* is employed. (3) *Vertigo* and a tendency to diplopia. (4) *Reflex symptoms* such as nausea and vomiting, dyspepsia, menstrual disturbances, chorea, and other nervous symptoms; the dependence of some of these reflex symptoms upon asthenopia is doubted by many competent observers.

The amount of asthenopia depends not only upon the degree of defect, but also upon the *state of the patient's health*, and is therefore pronounced in delicate, anæmic, and neurasthenic individuals.

Varieties.—1, Accommodative. 2, Muscular. 3, Nervous or neurasthenic (reflex). Two of these varieties may be associated.

Accommodative Asthenopia is the *most common* variety. It is due to *strain and fatigue of the ciliary muscle* when used too constantly or excessively, in *ametropia*. It is especially frequent in astigmatism and hyperopia, but is common enough in myopia and in presbyopia. *Treatment* consists in

the use of *glasses* correcting the error of refraction as advised in preceding pages. In delicate and neurasthenic individuals attention to the *general health* is very important.

Muscular Asthenopia is due to *weakness of the external ocular muscles.* It may be associated with ametropia and its existence be dependent upon the latter error, or it may occur in emmetropia. It is most frequently due to insufficiency of the internal recti muscles (*exophoria*), necessitating a strain upon these weaker muscles during convergence. It is often due to myopia, in which, on account of the far point being close to the eye, the patient is obliged to converge excessively. The tests and treatment are described in Chapter XXV.

Nervous, Neurasthenic, or Reflex Asthenopia is the variety which occurs in emmetropic patients or in ametropes in whom proper correcting lenses give no relief. The symptoms are ascribed to a functional error in the retina (anæsthesia and hyperæsthesia), or more commonly to a *lack of tone in the ciliary muscle.* It is a neurosis and is dependent upon a general asthenic condition of the nervous system; consequently it is found most frequently in young women with hysterical tendency, who suffer from anæmia, neurasthenia, and often menstrual disorders; also in neurasthenic individuals in general, and in convalescents from debilitating diseases. The condition is often very *troublesome* and frequently *obstinate. Treatment* consists in removing the defect in the *general condition, rest* of the eyes, and particularly *attention to hygiene,* such as the regulation of habits, out-door exercise, etc.

MYDIATRICS AND CYCLOPLEGICS.

The actions of these agents and the method of obtaining the best results with them are described in Chapter XXVI.

A *cycloplegic* is indicated in the estimation of the refraction *in all cases of children and young adults,* in many cases between the ages of 35 and 45, and occasionally between

45 and 50 when the previous determination of the refraction without paralysis of accommodation has been unsatisfactory. Before using these agents in elderly persons, any suspicion of *glaucoma* must be excluded.

Homatropine (two- or three-per-cent. solution), or homatropine, two per cent., combined with cocaine one per cent., is the agent most frequently employed; one drop is instilled every ten minutes for three or four doses, and the examination begun at the end of half an hour after the last instillation.

Exceptionally, homatropine fails to produce complete paralysis of accommodation, as shown by more or less contradiction in the results of the objective and subjective tests. In such cases, particularly in children affected with strabismus, we resort to *atropine* (one-per-cent. solution), one drop being instilled three times daily for two or three days (smoked glasses should be worn during this period), and a final drop directly before the examination.

In children and in young adults, it is proper to make one examination without a mydriatic, a second under the influence of homatropine, and then to base the prescription for glasses upon a comparison of these results, according to the rules given in the preceding pages.

THE FITTING OF EYEGLASSES AND SPECTACLES.

Much of the comfort and relief which lenses bring will depend upon the skill with which the glasses are *fitted to the face*. Whether the patient selects eyeglasses or spectacles, the lenses must be supported in their frames in such a manner that the distance between their geometric centres corresponds to the interval between the centre of the pupils (*interpupillary distance*).

If the glasses are to be worn constantly, the geometrical centre of the lenses should be slightly below the centre of the pupils, and the lenses *tilted* so that their surfaces form an angle of about 15° with the plane of the face. If worn

for distance only, the level of the lenses should be the same and the tilting about 10°. If worn for near work only, the lenses should be lower, and inclined about 25°.

In every case the glasses should be worn as *near the eyes* as possible, just avoiding the lashes.

Lenses are usually made of crown glass. The *periscopic* form of *spherical* lenses (p. 271) is preferred. In *cylinders*, one surface is generally plane and the other curved; but such lenses can also be ground with two curved surfaces, the cylinder corresponding to the outer surface. Sphero-cylinders usually have the spherical lens on one surface and the cylindrical lens on the other; but in "toric lenses" both the cylindrical and spherical curves are ground on the outer surface; this gives an enlarged field. Lenses cut from crystal are known as *pebbles*; they have the advantage of being less easily scratched.

Bifocal lenses consist of an upper portion of one focus, and a lower part of another. They are used principally in cases of presbyopia associated with ametropia, the lower portion being used for reading and near work, and the upper for distance. The best bifocal lenses are those in which the addition consists of a segment cemented to the lower portion of one surface of the distance glass (Fig. 207).

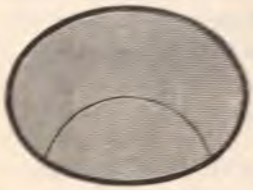


FIG. 207.—Bifocal Lens.

In cases of *astigmatism*, it is necessary that the *axis of the cylinder be constant*. On this account spectacles are often preferred to eyeglasses, because with the latter, the axis of the clyinder may vary according to how the glasses are worn or how they preserve their original adjustment. But eyeglasses can be worn in such cases, if the optician exercises sufficient skill in fitting.

CHAPTER XXIV.

ANOMALIES OF ACCOMMODATION.

PRESBYOPIA.

PRESBYOPIA or *old sight* is a *physiological change* which affects every eye, commencing *between the 40th and 45th years*, as a result of which the *near point recedes* beyond the distance at which we are accustomed to read ordinary print; this distance has been fixed somewhat arbitrarily at 22 cm. (about 9 inches). The change is due chiefly to *loss of elasticity of the lens*, whereby it is prevented from responding to the action of the ciliary muscle; consequently the *power of accommodation is lessened*. As explained on p. 289, this diminution in the power of accommodation begins early, about the 10th year. Between the 40th and 45th years it becomes sufficient to interfere with the comfortable exercise of near vision; then presbyopia is said to be present.

At the age of 40, there are 4.5 D. of accommodation, and the near point is at 22 cm. or 9 inches. To read at 9 inches, such an individual would require all of his accommodation and the effort would soon become fatiguing, since only one-half or two-thirds of this power can be used for any length of time without causing asthenopic symptoms. Generally, however, the adult holds print at about 13 inches (33 cm.), requiring 3 D. of accommodation and leaving a reserve of 1.50 D; this is usually sufficient to insure comfort. At 45 his accommodation has diminished to 3.5 D; all or nearly all of this would be required to read comfortably at 13 inches, leaving little or no reserve. If he keeps

one-third of his accommodation in reserve, he will have about 2.25 D. available for near work; with this, his reading distance would be 45 cm. or 18 inches—too great for comfortable and continuous near work. Hence we must supply the defect in the power of accommodation by a convex lens sufficient to bring the near point back to a convenient distance.

Symptoms.—The presbyope is compelled to hold reading, writing, sewing, and other forms of *near work farther away* than the usual distance, making such efforts *uncomfortable*. With this recession of the near point beyond the usual situation, the *print becomes pale and indistinct*, and fine type can be read only with great difficulty. The patient is apt to use strong illumination; this produces contraction of the pupil, and thus improves the definition by diminishing the circles of diffusion. If the condition be uncorrected, he suffers from *asthenopic symptoms*, especially pain, fatigue, lachrymation, dimness of vision, and irritation of the lids, all of these symptoms being more marked in the evening with *artificial illumination*. Presbyopia has *no effect upon distant vision*.

Treatment consists in prescribing *convex spherical lenses for near work* so as to compensate for the lack of power of accommodation, and to *bring the near point back to a comfortable working distance*, about 13 inches.

We can generally prescribe the correcting glasses *according to age*. The rule is to give +1 D. at 45, and to add 1 D. for every five years; this will bring the near point back to 22 cm. or 9 inches:

Age 45,	glass	required	+ 1 D.
" 50,	"	"	+ 2 D.
" 55,	"	"	+ 3 D.
" 60,	"	"	+ 4 D.
" 65 and over		"	+ 4.50 D.

The numbers just given are somewhat arbitrary; frequently we will find that a slightly weaker lens will be

sufficient. The *age* at which patients are obliged to wear glasses *varies* within a few years, and is influenced, to a certain extent, by the vigor of the individual; a delicate or neurasthenic person will require glasses for reading earlier than a robust individual.

The glasses must also be *selected with reference to the occupation or the special use* for which the patient wishes them. Thus in reading, writing, and sewing, 13 inches (33 cm.) is a comfortable working distance for most persons; but a musician may prefer a distance of 20 inches (50 cm.), and consequently he will require a weaker glass

To find the glass required, we note the patient's near point; then we estimate the lens which represents this point; finally we subtract this number from the lens whose focus corresponds to the distance at which the patient desires to work. For example, suppose the near point has receded to 50 cm. (20 inches); this is represented by a +2 D. lens ($\frac{100}{50}$ or $\frac{40}{20} = 2$). We wish to bring the near point to 33 cm. (13 inches), which corresponds to +3 D. ($\frac{100}{33}$ or $\frac{40}{13} = 3$). Hence +2 D. from +3 D. = +1 D., the glass required.

The existence of *ametropia* will modify the strength of glasses required for presbyopia. Hence the patient's vision for distance, and his refraction, must be determined before estimating the glasses required for near work. In any case of *ametropia* the *lenses required for distance must be added* to those which would be selected for presbyopia in the emmetrope. This would have the effect of increasing the strength of the convex lens required for presbyopia in cases of hyperopia, and of diminishing its power in myopia. For example, suppose a patient of 50 has hyperopia of 1.50 D.; his glasses for reading would be H. 1.50 + Pr. 2 D. = + 3.50 D. A myope of 2 D. will require no glass at 50, since −2 D. and +2 D. (Pr.) neutralize each other. At 55, he would require +1 D. instead of the usual +3 D. (−2 D. +3 D. = +1 D.). If the myopia amounts to 5.00

D., the patient will never require glasses for reading, since his near point will always be 20 cm. or 8 inches. *In astigmatism, the cylinders must be added* to the convex lenses required for the correction of presbyopia.

Since presbyopia increases with age, the *glasses will require changing* for stronger ones *every few years*. When the glasses have to be changed very frequently, we should suspect glaucoma and examine the eye carefully for this disease.

PARALYSIS OF ACCOMMODATION.

Paralysis of Accommodation (*Cycloplegia*) is a partial (paresis) or complete *loss of power in the ciliary muscle* due to paralysis of the *third nerve*, or of that branch of the motor oculi which supplies the ciliary muscle and iris. Though occasionally confined to the ciliary muscle, the paralysis usually includes the sphincter pupillæ. When limited to the ciliary muscle and iris, it is known as *ophthalmoplegia interna*.

Etiology.—The most frequent cause is the use of *mydriatics*, such as atropine and homatropine. It may be part of a *complete paralysis of the third nerve*. It occurs not infrequently after *diphtheria*. Other causes are *contusions* of the eyeball, debilitated states of the system, grippe, syphilis, diabetes, and cerebral disease.

Symptoms.—These are *loss of power of accommodation and dilatation of the pupil*. If emmetropic, the patient will have good vision for distance but be unable to do near work without convex glasses. If hyperopic, both near and distant vision will be impaired. If myopic, the patient will be able to see only at his far point; he may therefore be able to do without his accommodation, if the myopia is considerable.

Prognosis is *usually good*, especially when the affection is due to syphilis, diphtheria, or the use of a mydriatic. In traumatic cases the condition may be permanent.

Treatment.—We attempt to *remove the cause* of the paralysis: In syphilis, specific treatment is indicated. In post-diphtheritic paralysis, and in that due to debilitated conditions, *tonics* are given, especially *strychnine*. *Locally*, the *myotics* (eserine or pilocarpine) are employed. These cause contraction of the pupil and of the ciliary muscle, producing spasm of accommodation, and temporarily relieve the symptoms; the alternate contraction and relaxation of the ciliary muscle often stimulate it to action. The local application of electricity is sometimes useful. In traumatic cases, complete rest is indicated, in addition to the remedies just mentioned. If the paralysis has lasted some time, *convex glasses* may be given for near work.

SPASM OF ACCOMMODATION.

Tonic spasm of the ciliary muscle is frequently met with in *children* and in *young adults;* it occurs generally in *hyperopia*, but it may accompany any error of refraction.

Etiology.—It is usually due to *long-continued application* of the eyes for near work, especially when the young patient is in poor health, has uncorrected ametropia, and the work has been excessive and done with poor illumination.

Symptoms.—*Both eyes* are usually affected. There are *asthenopic symptoms and diminished acuteness of vision*. In emmetropia, the spasm gives rise to the signs of myopia; in hyperopia, it reduces the amount of manifest error and increases the proportion of latent hyperopia, or it may even cause the patient to appear myopic; in myopia the error is increased. The diagnosis is made after instilling a cycloplegic; in some of these cases homatropine is insufficient and *atropine* must be used.

Treatment consists in the *abstinence from near work, the correction of ametropia*, attention to the *general health*, and the production of paralysis of accommodation for a few days or weeks by instillations of *atropine*.

CHAPTER XXV.

[illegible] OF MOTILITY OF THE EYE.

Anatomy and Physiology.—The eyeball is moved by [illegible] muscles, consisting of the four [illegible]; these arise from the wall of [illegible] and are inserted into the sclera.

[illegible] (*internal, external, superior, and inferior*) [illegible] in the circumference of the optic foramen at the [illegible] forward surrounding the optic nerve [illegible] of the eyeball, and are inserted into [illegible] by means of flattened tendons about 10 mm. [illegible] The lines of insertion of these muscles are not [illegible] from the cornea, but have somewhat the form of a spiral: that of the internal rectus is 5 mm., of the inferior rectus [illegible] mm., of the external rectus 7 mm., and of the superior rectus 8 mm., from the cornea.

The superior oblique arises from the border of the optic foramen, runs forward to the upper and inner angle of the orbit, at the anterior extremity of which it passes through a fibrous pulley, it then continues outward, passing beneath the superior rectus, and is inserted into the upper part of the sclera behind the equator. *The inferior oblique* arises from the superior maxillary bone at the inner portion of the lower border of the orbit, passes outward below the inferior rectus, and is inserted into the outer part of the sclera behind the equator.

The muscles are ensheathed by the fascia of the orbit, *Tenon's capsule*, which also covers the sclera and sends prolongations to the walls of the orbit which serve to fix

the eyeball in its place. These prolongations are most prominent upon the internal and external recti muscles; they serve to restrain the excursions of the eyeball and are known as "*check ligaments.*"

Nerve Supply.—The *third* nerve (oculomotor) supplies all the muscles except the external rectus, which is innervated by the *sixth* (abducens), and the superior oblique, which is supplied by the *fourth* (trochlearis). The nuclei for these three nerves are found in the floor of the fourth ventricle.

Action of the Muscles.—The six extrinsic muscles serve to rotate the eyeball *around a vertical, transverse, and antero-posterior axis,* the centre of rotation corresponding approximately to the centre of the eyeball, and the movements being free in all directions, like a ball-and-socket joint. The movements which take place about the vertical axis are *adduction* (toward the nose) and *abduction* (toward the temple); about the transverse axis, *elevation and depression;* and about the antero-posterior axis, *wheel rotation or torsion,* by means of which the upper extremity of the vertical meridian is inclined inward or outward.

The external rectus moves the eyeball outward.

The internal rectus moves the eyeball inward.

The superior rectus moves the eyeball upward, inward, and turns the upper extremity of the vertical meridian inward.

The inferior rectus moves the eyeball downward, inward, and turns the upper end of the vertical meridian outward.

The superior oblique rotates the upper end of the vertical meridian inward, and moves the eyeball downward and outward.

The inferior oblique rotates the upper end of the vertical meridian outward, and moves the eyeball upward and outward.

Movements of the Eyeball.—In every movement of the eyeball *several muscles act at the same time,* as follows:

Adduction:	Internal Rectus. Superior Rectus. Inferior Rectus.
Abduction:	External Rectus. Superior Oblique. Inferior Oblique.
Elevation:	Superior Rectus. Inferior Oblique.
Depression:	Inferior Rectus. Superior Oblique.
Rotation of upper extremity of vertical meridian *inward.*	Superior Oblique. Superior Rectus.
Rotation of upper extremity of vertical meridian *outward.*	Inferior Oblique. Inferior Rectus.

Both eyes always move simultaneously (*associated movements of the eyes*). This association is regulated by centres of association which innervate certain muscles or groups of muscles of the two eyes simultaneously. The associated or conjugate movements occur either in the same direction, with the *visual lines parallel*, or with the lines inclined toward each other (*convergence*).

The Field of Fixation corresponds to the *limits of movement of the eyeball in different directions*, without moving the head. It is best estimated by the perimeter (Fig. 135). The patient's head is fixed so that the eye under examination is opposite the centre of the instrument. Large test types are now moved along the arc of the perimeter, from the periphery to the centre, until the patient can name the letters. The movements must be made with the eye alone, without any change in the position of the head, and the other eye must be covered. The field of fixation in the normal eye is about 45° upward, inward, and outward, and about 60° downward.

Binocular Vision and Diplopia.—Under ordinary conditions, both eyes are concerned in the act of vision, and are involuntarily adjusted, so that the image of an object is focussed on the macula of each eye. The object is then

perceived as single by the brain. This faculty constitutes *binocular vision.*

When images fall on symmetrical points of the two retinæ, a single visual sensation is produced (*binocular single vision*). When the visual lines of the two eyes are not directed toward the same object, *i.e.*, when one eye deviates, *diplopia or double images* result, unless the image of the deviating eye is disregarded or suppressed. The diplopia is proportional to the amount of deviation. The image which corresponds to the eye which "fixes" the object is distinct, because it lies at the macula, and is known as the *true image;* the image of the deviating eye is less distinct, because it is perceived by a peripheral part of the retina, and is known as the *false image.*

Objects which are situated to the right of the point of fixation throw their images to the left of the macula; and those placed to the left of the point of fixation form images to the right of the macula. In the same manner objects above or below the point of fixation cast their images below or above the macula respectively. By reversing this process we judge of the *situation of an object*, and place it *at the extremity of an imaginary line drawn from the retinal image through the nodal point.* This process is known as *projection*, and is learned by experience. It enables us to judge of the relative positions of objects. An object which forms its image to the right of the macula is situated to our left; one which throws its image below the macula is situated above, etc.

If an eye is deflected, an object situated straight ahead will form its image on either side of the macula, and following out this process of projection, it will be referred to the opposite side of the outside world.

Diplopia is said to be *homonymous* when the false image is on the *same side* as the deviating eye, and *crossed* when it is on the *opposite side.*

In Fig. 208, the right eye is turned in, and consequently

binocular diplopia results. The patient sees a true image with the left eye, the image of the candle forming at the macula and being referred to its proper place, *TI.* In the right eye, on account of the deviation inward, the image is thrown upon the retina to the left of the macula and consequently is projected to the right, at *FI.* The image of the right eye being to the right of the image of the left eye, the case is one of *homonymous double images.*

In Fig. 209, the right eye turns out and double images result. The image of the candle lies on the macula in the

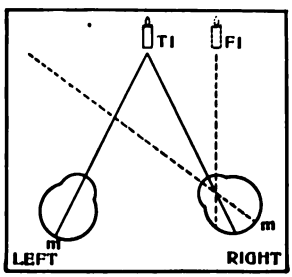


FIG. 208. Deviation of the Right Eye Inward. Homonymous diplopia. *TI.* True image; *FI.* false image; *m.* macula.

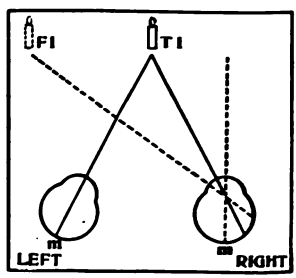


FIG. 209.—Deviation of the Right Eye Outward. Crossed diplopia. *TI.* True image; *FI.* false image; *m.* macula.

left eye, and this eye refers the image to its right position; a true image is seen at *TI.* In the right eye, because of its outward deviation, the image falls to the right of the macula and is consequently projected to the left, at *FI.* The images having crossed in their relative positions, that of the right eye being seen to the left of the image of the left eye, the case is one of *crossed diplopia.*

Double images may also be produced without any deviation, by placing a *prism* in front of the eyes. The prism will deflect the rays so that instead of falling upon the macula, they reach the retina to one side of it.

Varieties of Ocular Deviations:

1. *Paralysis,* marked deviation due to loss of motion in

one or more of the ocular muscles; when partial, it is known as *paresis.*

2. *Strabismus or Squint,* a decided manifest deviation which the patient cannot overcome.

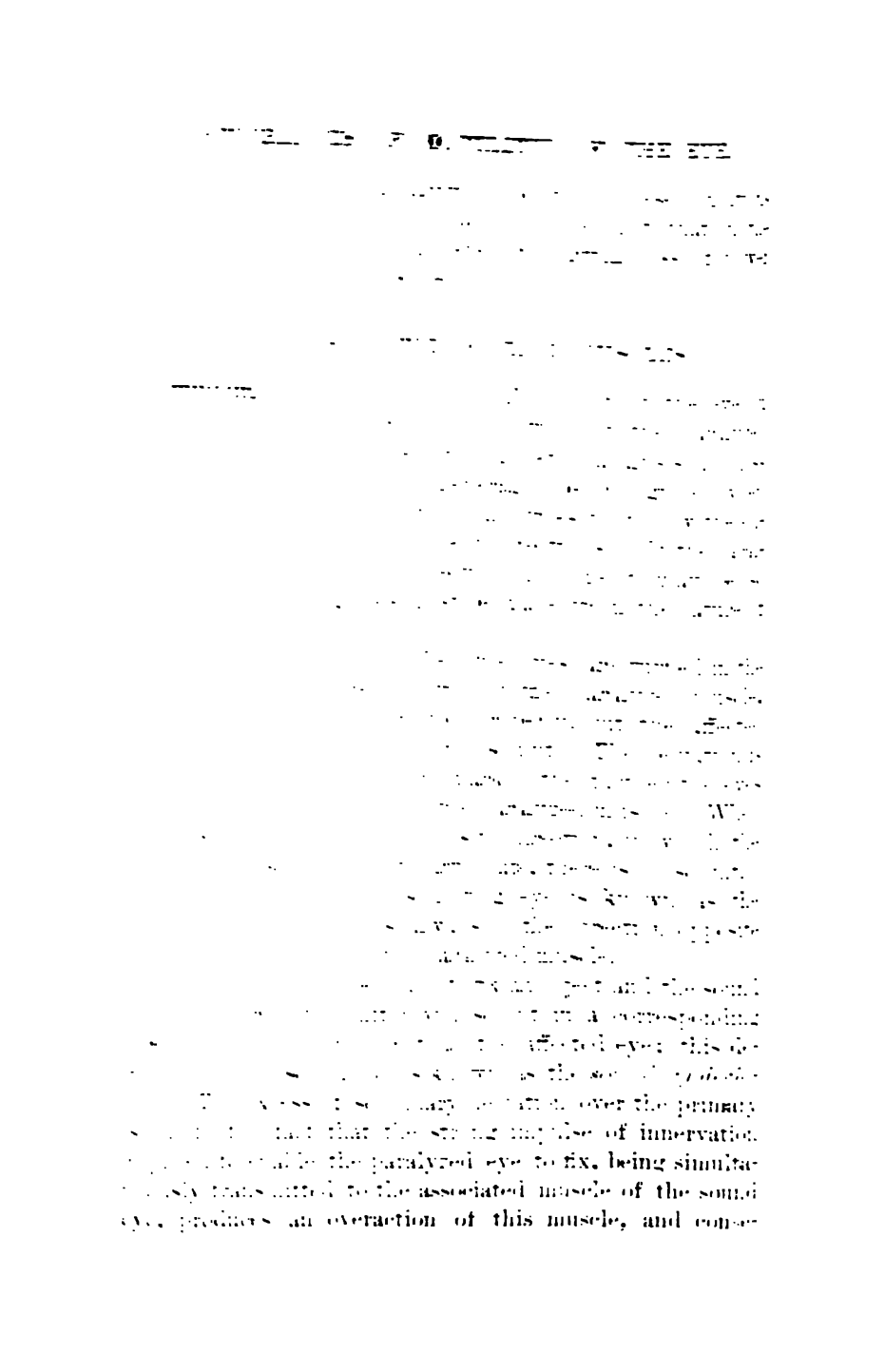
3. *Heterophoria or Insufficiency,* a slight or moderate deviation, which is latent. and habitually corrected by muscular effort.

The eyes are *properly balanced, or in a state of equilibrium,* when the visual lines meet at the object toward which they are directed. This condition is brought about by harmoniously distributed innervation of the muscles; it is known as *orthophoria.* Any disturbance of this muscular equilibrium causes a *lack of balance* or an "imbalance." In speaking of errors of this sort, we always take *both eyes* into consideration.

These muscular anomalies represent merely *differences in degree.*

In insufficiency or heterophoria, one eye deviates under cover; but when both eyes are used, the desire for single vision prompts a conveyance of increased innervation to the defective muscle or muscles, and this causes the visual lines to meet exactly at the object to which they are directed. The eyes are then placed in a condition of *forced equilibrium* by the expenditure of an amount of nervous force which frequently causes symptoms of *muscular asthenopia.* Under ordinary circumstances, therefore, the deviation is not apparent; hence it is called *latent deviation, or latent squint.*

In *squint or strabismus,* the deviation is more pronounced and cannot be overcome by increased innervation; the error is *manifest.* But there is *no distinct dividing-line between squint and insufficiency.* There are transition forms, which may be considered either as low degrees of squint, or as high degrees of insufficiency. Some cases of insufficiency represent the early stages of squint, and the causes, symptoms, and treatment of these two forms of deviation pre-



quently a greater amount of squint. This is an important point in distinguishing between paralytic and concomitant squint; in the latter, the primary and secondary deviations are equal.

3. *Oblique Position of the Head.*—The patient turns his head toward the side of the paralyzed muscle and in the direction in which the paralyzed muscle would, if acting, move the eye. This is done so as to diminish or correct the diplopia. Hence there is a *characteristic position of the head for every variety of paralysis.*

4. *False Projection.*—The paralyzed eye does not see objects in their correct location. The false projection is due to markedly increased innervation, conveyed to the nerve supplying the paralyzed muscle in an effort to force it to act; this gives the patient an erroneous idea of the position of the eye. It can be demonstrated by closing the patient's sound eye and telling him to point quickly at an object in front of him; the finger will be directed to the side of the object corresponding to the paralyzed muscle.

5. *Diplopia* occurs when the patient looks at an object situated *within the sphere of action of the paralyzed muscle,* and becomes more marked the more the eyes are moved toward this side. The presence or absence of diplopia, the relative position of the double images, and the increase or diminution of the distance between them in different parts of the field of fixation, form the most important means of diagnosticating the seat of the paralysis.

Method of testing for diplopia: This is done by means of a *lighted candle* held at about 10 feet in front of the patient, and moved about in different positions of the field of fixation. For convenience of record and study a diagram is used, consisting of two horizontal and two vertical lines, forming nine spaces (Figs. 210 to 215). The patient must keep his head fixed and merely move his eyes. A *red glass* is placed before one eye so as to distinguish its image. The candle is moved about in different positions of the field

of fixation, and the nature of the diplopia noted in each of the nine spaces. The data required are: (1) in which position of the field there is *single vision* and in which *diplopia;* (2) whether the diplopia is *homonymous or crossed;* (3) the relative *distance between the double images;* (4) whether the two images are on the same or on different *levels;* and (5) whether the images are *erect or inclined.*

The false image is situated in the direction of the normal action of the paralyzed muscle, and the distance between the double images increases in this direction, and diminishes in the opposite direction. In fact, *most of the symptoms*—the limitation of movement, the false image, the turning of the face and oblique position of the head, the faulty projection, and the increase in the distance between the double images—*are in the direction of the normal action of the paralyzed muscle.* The squint, absence of diplopia, and diminution in the distance between the two images, are the only symptoms occurring in the opposite direction.

6. *Vertigo, nausea, and uncertain gait* are frequent symptoms, dependent upon the diplopia and the false projection; they are relieved when the patient closes the paralyzed eye. On this account, patients frequently keep the affected eye closed or covered.

After paralysis has lasted a long time, the symptoms become less characteristic. The diplopia disappears because the image of the deviated eye is *suppressed,* faulty projection is corrected by newly acquired experience, and there occurs *contracture of the antagonist* of the affected muscle, increasing the squint.

When one muscle only is paralyzed, the diagnosis is easy; but when several muscles are involved, it is often difficult to determine the exact combination.

Varieties of Ocular Paralysis.—One muscle may be involved, or several muscles in various combinations may be affected. Paralysis of the external rectus is the most common; that of the superior oblique is frequent; isolated

paralysis of the remaining four muscles is much less common. Combined paralysis of some or all of the four muscles supplied by the third nerve is exceedingly common.

Paralysis of the External Rectus (Sixth Nerve).—There is limitation of movement outward; convergent squint; and the face is turned toward the paralyzed side. Homonymous diplopia upon looking toward the paralyzed side; the images are on the same level and parallel (slightly tilted

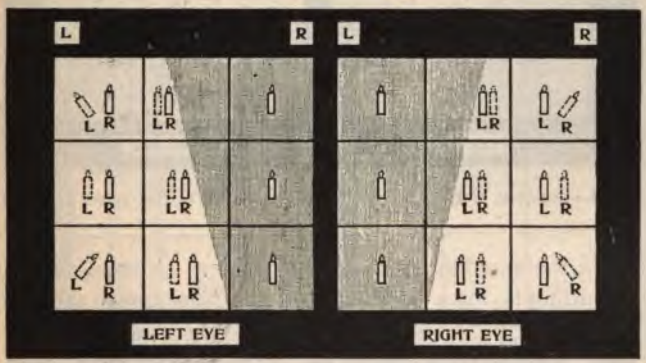


FIG. 210.—Paralysis of the External Rectus (the dotted outline refers to the false image).

in the upper or lower portions of the field); the lateral separation increases with abduction of the paralyzed eye (Fig. 210).

Paralysis of the Internal Rectus.—There is limitation of movement inward; divergent squint; the face is turned toward the sound side. Crossed diplopia, on looking toward the sound side; the images are on a level and parallel (slightly tilted in upper and lower portions of field); lateral separation increases with adduction of the paralyzed eye (Fig. 211).

Paralysis of the Superior Rectus.—There is limitation of movement upward and toward the sound side; deviation of the eye downward and a little outward, with the vertical

meridian inclined toward the temple; the face is directed upward and toward the sound side, and the head inclined

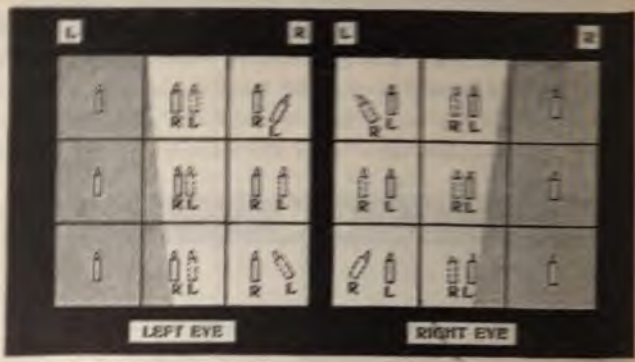


FIG. 211.—Paralysis of the Internal Rectus (the dotted outline refers to the false image).

toward the shoulder of the healthy side. Crossed and vertical diplopia upon looking up; the false image is higher

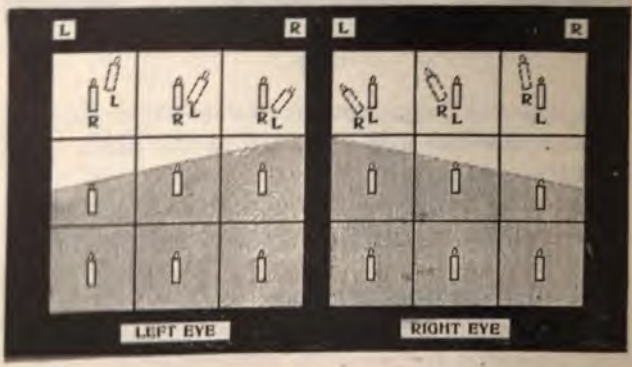


FIG. 212.—Paralysis of the Superior Rectus (the dotted outline refers to the false image).

and its upper end inclined toward the nose; the vertical distance between the images increases and the inclination

of the false image diminishes, upon looking upward and toward the paralyzed side (Fig. 212).

Paralysis of the Inferior Rectus.—There is limitation of movement downward and toward the sound side; deviation of the eye upward and slightly outward, with the vertical meridian inclined toward the nose; the face is directed downward and toward the sound side, and inclined toward the shoulder of the paralyzed side. Crossed and vertical

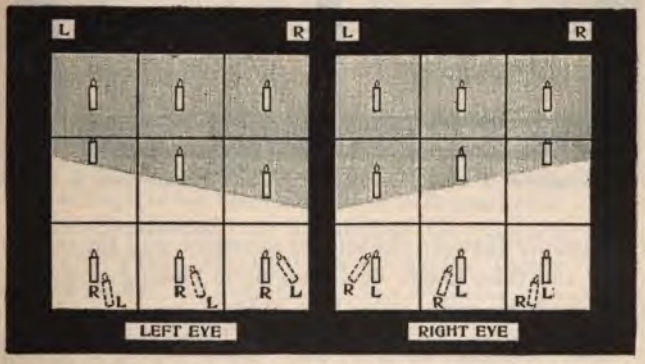


FIG. 213.—Paralysis of the Inferior Rectus (the dotted outline refers to the false image).

diplopia on looking down; the false image is lower, and its upper end inclined toward the temple; the vertical distance between the images increases and the inclination of the false image decreases, upon looking downward and toward the paralyzed side (Fig. 213).

Paralysis of the Superior Oblique (Fourth Nerve).—There is limitation of movement downward and toward the paralyzed side; the eye is deviated upward and slightly inward, with the vertical meridian inclined toward the temple; the face is directed downward and toward the sound side, and the head is inclined over the shoulder of the sound side. The patient has great difficulty in moving about, especially in going down-stairs. Homonymous and

vertical diplopia on looking down; the false image is lower and its upper end inclined toward the sound side; the ver-

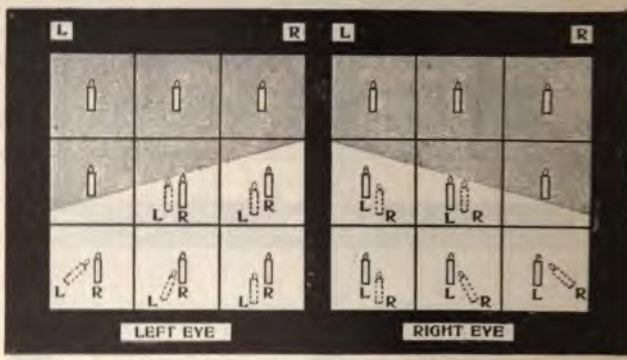


FIG. 214.—Paralysis of the Superior Oblique (the dotted outline refers to the false image).

tical distance between the images increases, and the inclination of the false image decreases upon looking downward and toward the sound side (Fig. 214).

Paralysis of the Inferior Oblique.—There is limitation of movement upward and toward the paralyzed side; the eye is deviated downward and slightly inward, with the verti-

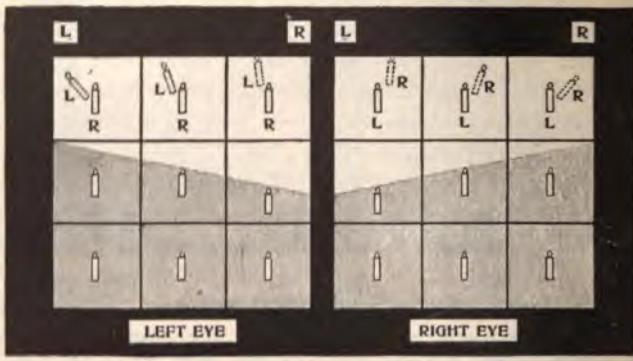


FIG. 215.—Paralysis of the Inferior Oblique (the dotted outline refers to the false image).

cal meridian inclined toward the nose; the face is directed upward and toward the paralyzed side, and the head is inclined toward the affected side. Homonymous and vertical diplopia on looking up; the false image is higher and its upper end inclined toward the temple; the vertical distance between the images increases, and the inclination of the false image decreases upon looking upward and toward the sound side (Fig. 215).

Paralysis of the Third Nerve.—With complete paralysis of this nerve there is *ptosis*: the *eyeball is almost immobile*, the limitation of movement being upward, downward, and inward; the *eye deviates outward* and somewhat downward, with the upper end of the vertical meridian inclined inward, especially upon looking downward; the face is directed upward and toward the sound side, and the head inclined to the shoulder of the paralyzed side. There is *slight exophthalmos* on account of the paralysis of the three recti which normally draw the eyeball backward; the *pupil is dilated and immobile; accommodation is paralyzed*; there is *crossed diplopia*—the false image is higher, and its upper end inclined toward the paralyzed side.

Paralysis of the third nerve is *common*: it is *often incomplete*, two or three of the muscles being affected. It may be associated with paralysis of other nerves.

When all the muscles of one eye are paralyzed, including the iris and ciliary body, the condition is known as *total ophthalmoplegia.*

When all the exterior muscles of the eyeball are paralyzed, but not the iris and ciliary body, the condition is known as *external ophthalmoplegia*. This form is more common than total ophthalmoplegia; the nuclei for the sphincter pupillæ and ciliary muscle being separate, they often escape involvement from destructive processes affecting the origin of the exterior ocular muscles. This form of paralysis is generally of central (nuclear) origin.

When only the sphincter pupillæ and the ciliary muscle

are paralyzed, the condition is known as *internal ophthalmoplegia* (p. 334).

Associated or Conjugate Paralyses involve associated muscles, such as the external rectus of one eye and the internal rectus of the other; they are due to lesions in the association centres.

Etiology.—The lesions causing paralysis may be situated anywhere in the course of the nerve tract, from the cerebral cortex to the muscle. According to its site, the lesion is distinguished as *central* and *peripheral*. *Central lesions* may be situated in the cortical centres (*cortical paralysis*), *the association* centres, the nuclei of origin (*nuclear paralysis*), or in the fibres which connect these centres. *Peripheral lesions* may affect the nerves in some part of their course, either between the point where they issue from the brain and their entrance into the orbit (*basilar paralysis*), or in the nerve or its branches in the orbit (*orbital paralysis*).

The Differential Diagnosis between Central and Peripheral Paralysis is not always easy; it is based on the character of the paralysis and the accompanying symptoms. Complete paralysis, unaccompanied by any other symptoms, is generally *peripheral*. When *central*, the paralysis is generally less complete, more than one muscle is usually involved, there are apt to be cerebral symptoms, and there is commonly an absence of peripheral cause.

The Nature of the Lesion.—The lesion may be a neighboring exudation, hemorrhage, periostitis, tumor, injury, or vascular change, causing compression or inflammation of the nerves; less frequently it is a primary inflammation or degeneration.

The most common cause is *syphilis* (late symptom). Other causes are *rheumatism* and gout, *exposure to cold*, *diphtheria*, *locomotor ataxia* and other spinal affections, tuberculous meningitis and other cerebral affections, dia-

betes, acute infectious diseases, toxic affections, and injuries. Occasionally paralysis is congenital.

Prognosis *varies with the cause.* Peripheral paralyses due to syphilis, rheumatism, and cold usually get well, but there may be *relapses.* In the paralysis accompanying serious spinal and cerebral disease, the prognosis is often bad. Long-neglected paralyses present an unfavorable prognosis, on account of the atrophy of the paralyzed muscle and the contraction of the antagonist. The course is always chronic, and even in favorable cases, several *weeks or months* are required to effect a cure.

Treatment should, in the first place, be *directed to the cause.* In syphilis, mercury and large doses of potassic iodide are given. In rheumatism and gout, salicylate of sodium, iodide of potassium, and colchicum, singly or combined, are prescribed. In diphtheria, strychnine is indicated. In obscure cases, potassic iodide with or without mercury is usually resorted to. Hot baths and diaphoresis are sometimes employed.

Locally, we may use electricity, muscle-stretching, ocular-muscle exercises, prisms, and occlusion of one eye. In incurable cases, operative intervention is resorted to.

Electricity may be tried; the constant current (3 milliampères) is used, the negative pole being applied to the back of the neck, and the positive over the affected muscle.

When the paralysis remains obstinate, *muscle-stretching* may be used. Under local anæsthesia, the conjunctiva over the insertion of the paralyzed muscle is seized with a fixation forceps, and the eye forcibly rotated to and fro a number of times during two or three minutes, so as alternately to stretch and relax the affected muscle.

The weakened muscle may be *exercised* by allowing the patient to look through a *prism* which almost corrects the diplopia, thus coaxing the paralyzed muscle into action. The same result can be achieved by having the patient move his head until the double images almost coalesce, and

then directing him to make a strong effort to fuse them without any further motion of the head. Such exercises are repeated ten times at each sitting, several times a day.

In chronic cases with moderate paresis, *prisms* may neutralize the diplopia and thus add to the patient's comfort. Prisms stronger than 4° for each eye (8° in all) cannot be worn on account of their weight and chromatic aberration.

During the course of treatment, the deviating eye should be *occluded* by a patch or a ground glass in an ordinary spectacle frame, so as to prevent the annoying diplopia.

If the condition persists for a long period in spite of all treatment, and the paralysis seems incurable, *operative treatment* is indicated. This consists in an *advancement of the paralyzed muscle*, combined in many cases with *tenotomy of the antagonist*. The results of this operation are often disappointing, but the cosmetic improvement may be satisfactory.

STRABISMUS OR SQUINT.

Strabismus or Squint (*Concomitant Squint*) is a *manifest deviation of the visual line of one of the eyes*, the two eyes maintaining the same faulty relationship of axes in every direction in which they are turned. The power of the different muscles of the two eyes is usually normal, and the squinting eye follows the other in all its movements, always deviating from the correct position to the same extent, and *the visual lines remaining at the same angle;* on this account, the condition is known as *concomitant squint*. It is a condition of *faulty co-ordination of the two eyes*. The eye which is directed toward the object looked at, is known as the *fixing eye*, the other as the *squinting eye*.

Squint differs from heterophoria or insufficiency only in degree; in the latter disorder the squint is latent; in strabismus it is manifest, and cannot be overcome by increased innervation.

Strabismus is distinguished from paralytic squint by presenting a normal range of movement of each eye, and the same deviation in all parts of the visual field. In paralysis, the deviation is present only in the sphere of action of the paralyzed muscle, and there is limitation of movement in a certain direction. In concomitant squint, the primary and secondary deviations are equal; in paralytic squint, the secondary deviation is greater than the primary. Diplopia is a prominent symptom in paralytic squint, while in concomitant strabismus it is seldom present.

Varieties.—Squint is said to be

Constant, when always present; such forms may be divided into alternating and fixed.

Alternating squint is one in which the patient fixes with either eye indifferently, the vision in the two eyes being about equal; or else one eye fixes for distance, and the other for near vision.

Fixed or unilateral squint is one in which the same eye habitually deviates; the vision in this eye is usually below that of the other.

Periodic Squint is present only at times, as after accommodating excessively, or when the system is deranged. This variety may disappear with non-operative treatment, or pass into the constant variety.

According to the *direction of deviation,* squint is divided into—

(1) *Internal* Squint, or *Strabismus Convergens,* the commonest form.

(2) *External* Squint, or *Strabismus Divergens.*

(3) *Vertical* Squint, upward (Strabismus Sursumvergens) or downward (Strabismus Deorsumvergens); this form is rare except as a sequel to paralysis of the superior or inferior rectus. Some vertical deviation, usually upward, not infrequently accompanies a convergent squint.

Diagnosis can usually be made by *inspection.* But in slight degrees this cannot be depended upon. A simple

test is made by means of the *hand or a card:* The patient is directed to fix a distant object and a card is placed alternately over one and then over the other eye. When either eye is covered it will deviate, and the other will move so as to be directed upon the object. The test is repeated for a near object. The movement of the squinting eye is called the *primary deviation*, and that of the sound eye the *secondary deviation;* in concomitant squint the two are *equal*.

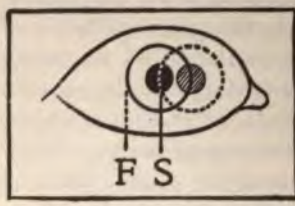


FIG. 216.—The Measurement of Squint by the Linear Method.

The Measurement of Squint.—The amount of strabismus may be measured by (1) markings on the lower lid, (2) by the strabismometer, and (3) by the perimeter.

The Linear Method presents a simple and fairly accurate measure (Fig. 216). The patient is directed to fix a distant object situated in the median line; the position of the outer margin of the cornea of the squinting eye is marked upon the lower lid margin (*S*, Fig. 216). Next, we cover the fixing eye and tell the patient to look at the same distant object with the squinting eye; as the latter begins to fix and is brought into proper position the location of the outer margin of the cornea is again marked upon the border of the lower lid (*F*, Fig. 216). The distance between the two marks (*FS*) gives the linear measure of the squint. Thus we say a squint of 2 lines, 4 mm., etc.

FIG. 217.—The Strabismometer.

The Strabismometer (Fig. 217) is a small ivory plate, having an upper margin curved to conform to the lower

lid, and marked with the inch or millimetre scale, by which the deviation of the centre of the pupil in the fixing and the squinting positions is measured.

The Perimeter (Fig. 13) gives the *angular measurement* of squint. The patient is seated with the squinting eye in the centre of the instrument, and is directed to fix a distant object placed in the median line, with both eyes. The quadrant is placed horizontal when the squint is convergent or divergent. A lighted candle is now moved along the inside of the arc from the centre outward, until its reflection on the cornea is seen in the centre of the pupil of the squinting eye. The number of degrees on the arc at this point indicates the size of the strabismus angle.

Symptoms.—The *cosmetic disadvantage* is the symptom which usually leads the patient to consult an oculist. There is *no diplopia* except in the very early stages, the double images soon disappearing owing to a psychical process of *excluding* the image of the squinting eye. There is *diminution in the acuteness of* vision of the deviating eye. This may or may not have existed previous to the development of strabismus; in either case, it increases with the duration of the squint as a result of *amblyopia ex anopsia* (from disuse), and may finally become very pronounced. Excepting in the commencement of strabismus, there are no asthenopic symptoms.

Etiology.—Concomitant squint is generally the result of a *reduction of the visual acuteness in one eye when there is a pre-existing disturbance of muscular balance.* This absence of muscular equilibrium (latent squint) would ordinarily result in a manifest strabismus, were it not for the fact that the patient keeps the eyes in proper position by an excessive innervational effort; if he fails to do this, there is deviation and troublesome diplopia. If, under these circumstances, something occurs which renders the vision in one eye less distinct, the diplopia becomes less annoying and more tolerable; consequently the same incentive no

longer exists for making the special effort to maintain the eyes in their proper position, and one eye is allowed to deviate.

The most common *causes* of such reduction in acuteness of vision leading to strabismus are: (1) *uncorrected errors of refraction* in one eye, or more in one eye than in the other; (2) *congenital amblyopia;* (3) *opacities of the media*, especially of the cornea, less frequently of the lens; and (4) *intraocular diseases.*

Concomitant squint may also be due to a paralysis of one of the exterior ocular muscles, in which contraction of the antagonist has set in, and in which the paralyzed muscle subsequently regains its power.

CONVERGENT CONCOMITANT STRABISMUS.

In this form of squint there is *deviation inward* of the visual line of one eye. It is generally due to *hyperopia*, this error of refraction being found in at least three-quarters of all cases; occasionally it occurs in myopia and in emmetropia. It usually commences in *early life*, between the *third and sixth years*, when the child begins to use his accommodation for near objects, such as toys and pictures; rarely it is congenital. At first the squint may be noticed only at times (*periodic*), with near vision, or when there is any interference with the general health; but it is apt to become *constant* for both near and distant vision; occasionally it disappears, especially if there is good sight in both eyes.

The *acuteness of vision* in the squinting eye usually presents *considerable reduction*, and there may be marked *amblyopia*. Whether the squint precedes and is the cause of the amblyopia, or whether the amblyopia is originally present and is responsible for the squint, is one of the much-discussed but unsettled questions in ophthalmology.

The frequent association of convergent squint and hyper-

opia depends upon the intimate connection between *accommodation and convergence.* A child who is hyperopic must use some accommodation for distance, and considerably more for near vision. Since accommodation and convergence are associated, he must increase his convergence with any increase of accommodation. In looking at a near object, the stimulus to converge would correspond not only to the amount present in the emmetrope, but would include an additional and abnormal amount called for by the extra accommodation required to compensate for his hyperopia Such a child, finding that he cannot accommodate and converge sufficiently without seeing double, must reduce his accommodation or his convergence: he must either give up some accommodation and content himself with the amount normally associated with the necessary convergence, thus retaining binocular with indistinct vision; or else he may retain the necessary amount of accommodation to insure distinct images, and *give up binocular vision.* He usually chooses the latter course, abandons binocular vision, and acquires convergent squint, especially when the vision is reduced in one eye as a result of opacities of the media, amblyopia, or greater refractive error.

Treatment consists in prescribing proper glasses, mydriasis, exercising the amblyopic eye, prism and stereoscopic exercises, and operation.

Non-Operative Treatment.—*The error of refraction should be estimated under atropine,* and *convex glasses* correcting, if possible, the *total hyperopia* prescribed for *constant wear.* In slight cases, especially if periodic, this not infrequently effects a cure. Glasses may be worn by children of three years and upward. Use of the eyes for near work should be forbidden. It is sometimes advisable to keep the eyes under the influence of *atropine* for several weeks.

The fixing eye should be covered by a patch or bandage for 15 to 30 minutes, three times a day, so as to compel

the squinting eye to concern itself in the process of fixation, and thus to be *exercised* and escape amblyopia from disuse.

Exercises by means of *prisms*, or with the *stereoscope*, are useful adjuncts in the non-operative treatment of convergent squint. They require so much patience and perseverance, however, that they are not frequently made use of, except after an operation for the relief of the squint; then they aid in the re-establishment of binocular vision.

Operative Treatment. — The non-operative measures mentioned above are successful in only a minority of cases, representing slight degrees of periodic squint of short duration. *In most instances operative treatment is required.* This consists in a *tenotomy* of one or both *internal recti muscles*, or in tenotomy of the internal rectus combined with *advancement of the external.*

If non-operative measures do not cure or produce marked improvement in from six months to a year, operation is indicated. It is not customary to operate before the *seventh year*, unless the squint be very well marked. There are, however, competent oculists who advocate operation at a much *earlier age.* When the squint has become fixed, it is in most cases impossible to give binocular vision, and operation merely relieves the *disfigurement.*

The choice of operation—whether tenotomy of one or both interni, advancement of one or both externi, or a combination—depends upon the amount of squint, the lateral excursions of both eyes, the amount of amblyopia in the squinting eye, and upon other conditions brought out by careful examination. *Every case must be decided upon its own merits. Tenotomy* is the easier operation, quickly performed, causing but little pain and little inconvenience to the patient. *Advancement*, on the other hand, is more difficult, tedious, painful, usually requiring a general anæsthetic, and the patient is confined to the house for several days. It is claimed that it is more rational to strengthen

a weaker muscle by advancing its insertion, than to weaken a stronger one by tenotomy. The relative advantages of the two forms of operation have been much discussed. A good general rule is to resort to tenotomy when there is considerable overaction of the internal recti with normal power of the externi, and to advance one or both externi when there is relaxation of these muscles with decided limitation in abduction.

The estimation of the result likely to follow operative treatment requires considerable judgment and experience. A free tenotomy of one internal rectus will usually cure a squint of about 14° (3 to 5 mm.). As a rule, only one internal rectus should be divided at a time, unless the squint be very marked, since it is difficult to gauge the after-effect correctly. The full effects of such operations frequently are seen only after several months or a year; if too much has been done, there will be divergence. In young children, a general anæsthetic is usually required; in older children, local anæsthesia will suffice.

DIVERGENT CONCOMITANT STRABISMUS.

This form of squint exists when one eye fixes an object and the other *deviates outward.* It is usually dependent upon *myopia;* near-sightedness is present in two-thirds of all persons with divergent squint. But it may occur with other errors of refraction. It is also observed after tenotomy for the cure of internal squint, and when the *sight in one eye is deficient* or abolished, as in opacities of the media, ocular disease and injury, and in blindness; in these cases, binocular vision being impossible, there is no need for convergence. Divergent squint is much less frequent than convergent.

Association with Myopia.—In myopia little or no accommodation is needed for near vision; consequently, there is an habitual deficiency of the stimulus for convergence, and

a tendency to relax the internal recti muscles. Again, the excessive convergence necessary to see near objects within the far point causes fatigue of the interni, giving rise to muscular asthenopia (p. 328); to relieve this, one of the internal recti muscles relaxes, and the eye turns out, especially if the sight in this eye is defective. Another predisposing cause of the frequent association of divergent squint with myopia is the increased antero-posterior diameter of the eyeball, which mechanically limits convergence.

Unlike convergent squint, the condition is infrequent in very young children. It *develops during youth*, when near-sightedness is established, and the tendency increases with the degree of myopia. When this error reaches a high degree, the far point is so closely approximated, that it is impossible to maintain the necessary covergence, and divergence becomes inevitable. At first, the squint is manifest only during near use of the eyes (*periodic*); but it usually progresses and is present in distant as well as with near vision (*constant*).

Treatment.—If the squint still be periodic and the patient's vision is good, we may attempt to cure the squint by giving the *full correcting lenses*. But as a rule, *operation is the only successful method of treatment. Tenotomy of one or both external recti* may be performed. But the effect will be very limited, and if the squint be pronounced, the result will generally be insufficient and unsatisfactory. The best results are obtained from *advancement of one or both internal recti*, a more rational operation considering that the condition is apt to be one of weakness of the interni, and not excessive action of the externi.

TENOTOMY.

The following description applies to tenotomy of the right internal rectus. The *methods of operating* employed most frequently are the *subconjunctival* (*Critchett's*) and the *open* (*Graefe's*).

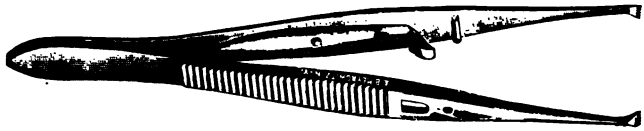
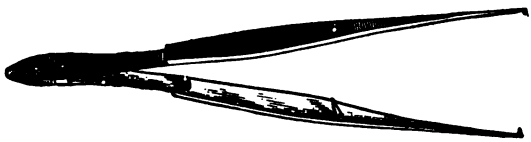


FIG. 218.—Fixation Forceps.



219.—Toothed Forceps.

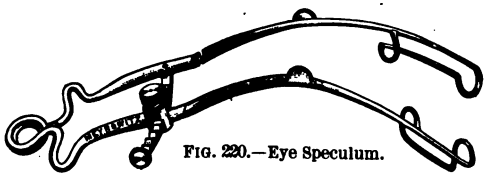


FIG. 220.—Eye Speculum.

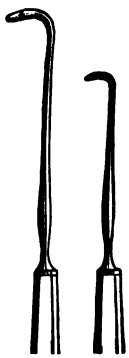


FIG. 222.—Large and Small Squint Hooks.

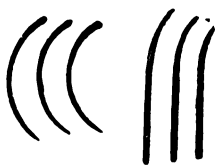


FIG. 221.—Fine Curved and Half-Curved Needles.

FIG. 223.—Curved Strabismus Scissors.

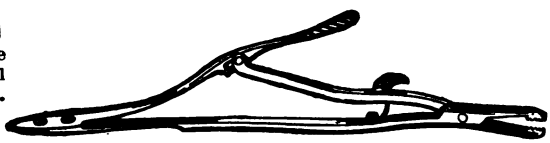


FIG. 224.—Sand's Needle Holder.

FIGS. 218-224.—Instruments Required for Tenotomy.

Instruments Required.—(1) Eye speculum (Fig. 220); (2) two pairs of fixation forceps (Fig. 218); (3) toothed forceps (Fig. 219); (4) blunt-pointed, curved strabismus scissors (Fig. 223); (5) two squint hooks (Fig. 222); (6) needle holder (Fig. 224); (7) fine curved and half-curved needles (Fig. 221); and thin black silk.

The Subconjunctival Method.—The speculum is introduced and the eyeball drawn downward, if necessary, by an assistant. The conjunctiva over the lowest portion of the insertion of the muscle, together with the subconjunctival tissue and Tenon's capsule, is seized with a pair of fixation forceps, raised and divided with scissors; the first cut divides the conjunctiva, the second Tenon's capsule. Keeping the fold raised with the forceps, a strabismus hook is introduced through the opening, passed beneath the tendon, and pushed upward until its point is seen through the conjunctiva at the upper border of the muscle. The hook is transferred to the left hand and raised so as to lift the tendon. The scissors are taken in the right hand and introduced, one branch between the tendon and conjunctiva, and the other between the tendon and sclera; the tendon is divided close to the sclera by two or more small cuts. The hook is reintroduced to make sure that no portion of the tendon has been left undivided. If the tendon has been completely divided, the hook can be advanced to the cornea without resistance; if not, the undivided fibres must be cut with scissors. The hook is again introduced and swept from behind forward, above, and below, to ascertain whether there are any uncut fibres of attachment to the sclera which, if found, must be severed. The conjunctival wound is closed with one or two vertical sutures.

The Open Method.—The steps are the same as in the preceding operation except that the muscle is exposed. The conjunctiva is incised about 2 mm. from the corneal margin, and dissected backward and downward beyond the *lower border of* the muscle. The hook is inserted beneath

the fully exposed muscle, which is raised and divided close to the sclera.

After-Treatment.—The result of the operation should be noted shortly after completion, if the patient is not under a general anæsthetic; in the latter case, we must wait for this to wear off. It may be necessary to *lessen the effect by a suture* which stitches the muscle forward to the insertion of the tendon; or to *increase the effect* by again introducing the hook and dividing the upper and lower extremities of the insertion of the tendon, or by rotating the eyeball in the opposite direction and keeping it in this position by a suture.

There should always be *some convergence left* after the operation since, although the primary result usually diminishes for a few days, the subsequent effect increases for a number of months or even a year or two. Hence if the immediate correction be perfect, there is apt to be subsequent divergence.

To increase the effect of the operation, *atropine* should be instilled and both *eyes bandaged* for a few days. If we do not desire such an increase in correction, this is unnecessary. There is usually no great reaction; the eye is bloodshot, but not painful. The bandage can be left off on the following day. Sometimes there is slight deformity caused by a *sinking of the caruncle*, the result of free division of Tenon's capsule. Infection and suppurative inflammation have occurred in rare instances, emphasizing the necessity for strict asepsis.

ADVANCEMENT OF AN OCULAR MUSCLE.

Advancement brings the *attachment of the muscle forward* and thus increases its power of moving the eyeball. It is *usually combined with tenotomy of the antagonist.* The more forward the tendon is secured in its new position, the greater the result of the operation. Since the effect dimin-

ishes after a time, it is advisable to *over-correct*. A *general anæsthetic* is usually required. The *instruments* required are practically the same as those needed for tenotomy. The following description applies to advancement of the right internal rectus:

Operation.—The speculum having been introduced, the conjunctiva is divided vertically by an incision 10 mm. long, midway between the cornea and the insertion of the muscle. The conjunctiva is then undermined up to the corresponding half of the corneal margin, and also backward so as to expose the tendon. Tenon's capsule is cut into at the lower border of the muscle, the latter secured upon the hook, the point of which is made to emerge above the tendon, and all connections with the sclera are divided. Three strong sutures are then passed from behind forward, one through the centre, one near the upper, and one near the lower margin of the muscle, Tenon's capsule and the conjunctiva being included. The tendon, now secured by the sutures, is divided at its insertion; if a decided effect is desired, a small piece may be excised. The middle suture is passed beneath the conjunctival flap and the needle pushed through the outer layers of the sclera, coming out at the corneal margin in the horizontal meridian. Then the upper and lower sutures are passed obliquely beneath the undermined conjunctiva, and the needles pushed through the outer layers of the sclera above and below the cornea, coming out in the vertical meridian. The sutures are tied more or less tightly according to the effect desired, the eyeball being rotated inward so as to facilitate this step. The conjunctival wound is closed by a few superficial stitches. The eye is bandaged, and the patient kept in bed for twenty-four hours, and confined to his room for two or three days. The stitches are usually allowed to remain in for about a week, unless we wish to diminish the effect of the operation.

INSUFFICIENCY OR HETEROPHORIA.

Insufficiency (heterophoria, *latent squint*) is a condition in which the eyes have a *constant tendency to deviate*, but are forced into simultaneous fixation of an object by special exertion. If this effort were not made, there would be a slight deviation and double images. So as to secure binocular vision and avoid diplopia, *an excessive amount of innervation is employed to maintain proper though forced balance.* When one eye is covered, diplopia cannot occur; hence the eye will deviate; its direction now represents the position of rest. The condition differs from concomitant squint only in degree; in the latter affection, the deviation is more pronounced and cannot be overcome by increased innervation.

Varieties.—The following terms are now generally employed for designating the various forms of latent squint:

Orthophoria, perfect muscle balance.

Heterophoria, imperfect muscle balance.

Exophoria, a tendency to deviate outward; latent divergence; insufficiency of the interni.

Esophoria, a tendency to deviate inward; latent convergence; insufficiency of the externi.

Hyperphoria, a tendency of one eye to deviate upward; right hyperphoria, when the right eye tends to deviate upward; left hyperphoria, when the left eye tends to diverge upward.

Hyperexophoria and *hyperesophoria*, a combination of hyperphoria with exophoria and esophoria respectively.

Etiology.—In a general way, the causes of latent squint are the same as those of concomitant strabismus. The chief cause is some *error of refraction*, especially when accompanied by some *disturbance in the normal relationship between accommodation and convergence.* Another very

common cause is *general lack of muscular tone* seen in delicate individuals and in convalescence from systemic diseases. Much less frequently, *certain anatomical conditions*, such as a defect or weakness, or abnormality in size or insertion of one of the muscles, is responsible. The condition is *very common*.

Symptoms.—*In slight degrees* of heterophoria, there are very often *no symptoms* whatever. In *more pronounced forms*, the symptoms of *muscular asthenopia* are present: Headache, various neuralgias, mental dulness, pain in the eyes, indistinctness or "running together" of print, diplopia, vertigo, and irritable condition of the lids. In *exophoria*, these symptoms are complained of most after use of the eyes for *near* work, in *esophoria* with *distant* vision. Sometimes the patient complains of one eye turning in or out. Not infrequently there is a feeling of ocular soreness in the morning upon awakening. The dependence of epilepsy, chorea, and other serious nervous disorders upon heterophoria is extremely doubtful, but neurasthenia and disturbances of digestion and nutrition may be the result of the muscular error in predisposed individuals.

Tests are usually carried out both at *20 feet* and at *13 inches*. The best *test object* for distance is a *candle flame*, and for near, a *black spot* (1 to 2 mm.) *upon a white card*. Since the deviation is latent, its presence is revealed only by certain tests. When the eyes are in a state of *perfect balance*, there is *orthophoria for distance* and usually a *slight exophoria* (corrected by a prism of 2° to 3°) *for near*.

The Cover Test.—The patient is directed to look at a distant object (20 feet), placed in the median line on a level with his eyes. A *card* is placed over one eye, and then over the other alternately, and the examiner notes the position and movement of the eye at the moment of uncovering. If on exposing the right eye and placing the card over the left, the right eye moves in, in order to fix the object, there must have been a deviation outward when

covered (exophoria). If on being uncovered the eye moves out, there is esophoria. If when the right eye is uncovered it moves down, there is right hyperphoria; if it moves up, there is left hyperphoria.

The test is repeated for a *near object* (a pencil, for instance) held in the median line and on a level with the patient's eyes, at about 13 inches.

The amount of movement of readjustment is proportional to the degree of deviation. Deviations of 2° or more are readily discovered by this test.

The Fixation Test.—The patient is directed to fix a small object, held in the median line on a level with the patient's eyes, and slowly advanced toward the patient's nose, to within two inches. If there is weakness of the interni (exophoria), one of the eyes will deviate outward before this *convergence near point* is reached.

The Maddox Rod is a piece of glass rod set in a hard rubber disc, so as to fit into the trial frame (Fig. 225). It converts the image of the flame perceived by one eye into a long streak of light (Fig. 226), so that there remains no desire to unite it with the image of the other eye. The line is always at right angle to the axis of the rod.

FIG. 225.—Maddox Rod.

The Maddox rod is placed horizontal before the right eye, converting its image of the candle flame into a vertical streak. If orthophoria is present, this streak appears to pass directly through the image seen with the other eye (Fig. 226).

If the line of light appears to the left of the flame, there is crossed diplopia indicating exophoria (Fig. 227); if to the right of the flame, there is homonymous diplopia, indi-

cating esophoria (Fig. 228). The amount of heterophoria is measured by the prism, base in or out, which serves to displace the streak until it runs directly through the flame.

The rod is then placed vertical before the right eye, converting the image of this eye into a horizontal line of light.

FIG. 226. FIG. 227. FIG. 228.

FIG. 226.—The Maddox Rod Test in Orthophoria.
FIG. 227.—The Maddox Rod Test in Exophoria.
FIG. 228.—The Maddox Rod Test in Esophoria.

If this is below the image of the flame seen with the left eye, there is right hyperphoria (Fig. 231); if above, there is left hyperphoria (Fig. 230). The degree of hyperphoria

FIG. 229. FIG. 230. FIG. 231.

FIG. 229.—The Maddox Rod in Orthophoria.
FIG. 230.—The Maddox Rod in Left Hyperphoria.
FIG. 231.—The Maddox Rod in Right Hyperphoria.

is measured by the prism, base up or down, which causes the light streak to pass directly through the flame.

Any *strong convex cylinder* will answer the same purpose. The Maddox rod is sometimes made of red glass, or a piece

of red glass is held in front of one eye, so as to color one image and thus effect a still greater reduction in the tendency to fuse the two images. A piece of *red glass* held in front of one eye is sufficient in itself to cause diplopia, whenever the heterophoria is marked.

The Graefe Test consists in placing a *prism of 10°*, base up or down, before one eye, thus *causing vertical diplopia*. If there is orthophoria, one image of the flame at 20 feet appears directly below the other. But if there is heterophoria, a lateral separation of the images is added to the vertical displacement caused by the prism. A second prism, base in or out, which brings one image exactly over the other, is the measure of the heterophoria.

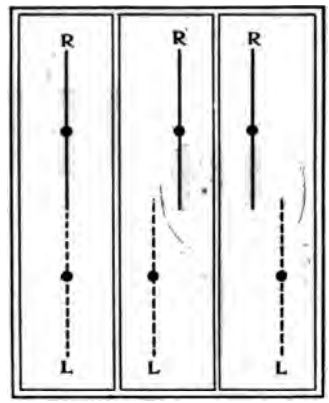


FIG. 232. FIG. 233. FIG. 234.

FIG. 232.—The Graefe Test. Orthophoria.
FIGS. 233 and 234.—The Graefe Test. Heterophoria.

This test is frequently used for estimating the disturbance of equilibrium with *near vision*. A black dot (2 mm.), and a vertical line 2 or 3 inches long passing through its centre, are drawn upon a white card. The latter is held at 13 inches, and a prism of 10°, base up or down, is placed before one eye. If there is orthophoria, the double images of the dot will appear one above the other (Fig. 232); if heterophoria, they will be displaced laterally, and there will be two dots and two lines (Figs. 233 and 234). The prism, base in or out, which brings them in the same vertical line is the measure of the deviation.

The Phorometer (Fig. 235) furnishes a rapid and con-

venient means of applying *the Graefe test*. It consists of a pair of 4° prisms. The latter are first placed with their bases up and down so as to produce vertical diplopia. If the double images do not appear one exactly over the other, there is exophoria or esophoria. By rotation of the prisms, the images can be brought in a vertical line, and the degree of rotation required read off on an attached arc indicates the amount of exophoria or esophoria. Hyperphoria is determined in a similar manner, the prisms being placed with

FIG. 235.—The Stevens Phoromoter (the base and upright have been omitted from the illustration.)

their bases in. The test object for near is a small metal plate, in the centre of which is a small opening or cross.

It is important to *measure the power of the muscles* in adduction, abduction, and sursumduction, as expressed by the strongest prism which can be overcome. *Adduction or prism convergence* is determined by ascertaining the strongest prism, base out, which the eyes can overcome—*i.e.*, converge so as to prevent diplopia; in normal eyes this amounts to a prism of 20° to 30°. *Abduction or prism divergence* is determined by the strongest prism, base in, which the eyes can overcome; it is represented normally by a prism of 6° to 8°. The usual relationship between adduction and abduction is about 3 to 1; the power of adduction can, however, be increased by practice. *Sursumduction* or the power of *vertical divergence* is measured by the strongest prism, base up or down, that can be overcome; it is usually represented by a prism of 2° or 3°.

Treatment consists in correction of the error of refrac-

tion, attention to the general health, prism exercises, the wearing of prisms, and as a last resort, operation.

1. *Correction of the Refractive Error* is of the greatest importance, and frequently is curative. In esophoria the full and constant correction of hyperopia is indicated. In exophoria, a partial correction of the hyperopia, so as to favor accommodation and divergence, is often advisable. In exophoria it is important fully to correct any myopia, and to direct such glasses to be worn constantly, if possible.

2. *Attention to the General Heatlh* is a necessary and valuable adjunct to local treatment. *Tonics* (especially strychnine), hygienic improvement, regulation of habits, and particularly plenty of *out-door exercise* are indicated, especially in neurasthenic and delicate individuals.

3. *Prism Exercises* serve to *develop and strengthen* the insufficient ocular muscles, by stimulating the latter into increased action.

In *exophoria*, prisms with bases out are supported before the patient's eyes, and he is directed to look at a lighted candle placed 20 feet distant. As soon as the double images come together, the prisms are lifted, and after a rest of a few seconds they are replaced. Commencing with 5°, the strength of the prisms is increased every few days, until the patient can easily fuse the double images produced by a pair of 20° prisms. The exercises are continued for a few minutes, several times a day. Whenever there is difficulty in bringing the double images together, the patient must approach the light until the fusion is easily accomplished, and then gradually increase the distance from the candle.

In *esophoria*, if symptoms persist after suitable correction of the error of refraction, prism exercises, bases in, may be tried; they offer, however, less chance of success than in exophoria.

In *hyperphoria*, prism exercises, base down or up, are sometimes beneficial.

The Wearing of Prisms is indicated if correction of the refractive error, improvement in general health, and ocular muscle exercises have failed to relieve the symptoms. The strength of the prisms prescribed should correspond, as a general rule, to about *half the deviation*, though sometimes a full correction gives comfort. The wearing of prisms does *not correct the deviation*, but may remove the discomfort. Only *weak prisms* can be worn, since those of greater

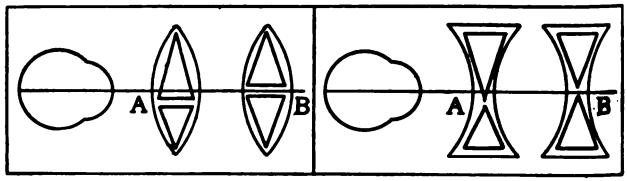


FIG. 236. FIG. 237.

FIG. 236.—The Prismatic Effect of Decentering a Convex Lens. *A*, Convex lens decentered downward; *B*, optical centre corresponds to geometrical Centre.
FIG. 237.—The Prismatic Effect of Decentering a Concave Lens. *A*, Concave lens decentered downward; *B*, optical centre corresponds to geometrical centre.

strength than 4° cause chromatic aberration and are uncomfortably heavy. In exophoria the bases are turned in, in esophoria out, in hyperphoria up or down. The relief from the wearing of prisms is often merely *temporary*. Such correction should not be continued for too long a time, since it usually causes an increase in the deviation.

If lenses are worn, the *effect of a prism* may be obtained by *decentering the lenses*—that is, displacing the optical centre so that it no longer corresponds to the geometrical centre of the glass (Figs. 236 and 237). *Decentering a convex lens in*, or a *concave lens out*, produces the effect of a *prism* with its *base toward the nose;* decentering a convex lens up or a concave lens down gives the effect of a prism with its base up. A lens of 1 D. must be decentered 8.7 mm. to produce the effect of a prism of 1°. To calculate the amount of decentering necessary to produce a certain prismatic effect, we multiply 8.7 by the value of the prism,

and divide the result by the strength of the lens in diopters. For example, a +4 D. lens ⌒ prism of 2°, base in, equals $\frac{8.7 \times 2}{4} = 4.3$ mm.; such a lens should be decentered inward 4.3 mm. in order to have the added effect of a prism of 2° base in.

5. *Operation* should be resorted to only as a *last resort*, after all other measures have been tried and the affection continues troublesome, because we can never be sure of the result. *Disappointment* often follows, and an *aggravation* of symptoms with added and annoying diplopia is not infrequent after operation for the correction of latent squint. As a general rule, operation is contraindicated unless the *deviation is considerable*, and unless the wearing of prisms has seemed to *prove the dependence* of the symptoms upon the heterophoria. A *limited or partial tenotomy* may be done upon one or both muscles which seem to overact, or a *limited or partial advancement* upon one or both antagonists. The latter operation is less apt to prove disappointing and mischievous, and is, consequently, the safer.

Partial Tenotomy and Partial Advancement.—In these operations a small opening is made into the conjunctiva over the insertion of the tendon. In *tenotomy*, the central portion of the tendon is seized and cut, and this incision extended toward both borders, leaving the peripheral portions intact; the effect is measured after each cutting, until the result is sufficient. In *advancement*, the central portion of the tendon is dissected from the eyeball and stitched forward. The instruments used resemble those employed for ordinary tenotomies and advancements, but are of more delicate construction. These operations, though practised quite frequently, are criticised unfavorably by many oculists; the effect is uncertain, and the operation must be repeated a number of times before a decided result is obtained.

NYSTAGMUS.

Nystagmus is a short, *rapid, involuntary oscillation of the eyeball*, usually affecting *both eyes* and associated with *imperfect vision*. The movements are most frequently from side to side (*lateral nystagmus*) or around the antero-posterior axis (*rotatory nystgamus*), sometimes up and down (*vertical nystagmus*). There may be a combination of the lateral or vertical with the rotatory movements (*mixed nystagmus*) The oscillations are similar in kind, duration, and frequency in the two eyes. They may be constant or present or exaggerated only when the eyes are turned in certain directions. The patient is *not*, as a rule, *inconvenienced* by the existence of this condition; but when it commences in adult life there may be much annoyance from the apparent movements of objects.

Most cases exist from *infancy*, and depend upon *diminution in the acuteness of vision or amblyopia* as a result of opacities of the media, intraocular diseases, albinism and other congenital anomalies, and very marked errors of refraction; in such instances the affection is due to defective vision, which prevents the infant or child from learning to perform fixation properly.

In adults it may develop with many *cerebral affections*, especially disseminated sclerosis. It is also found in coal miners (*miner's nystagmus*); in these cases it is due to working in a recumbent position, requiring the eyes to be turned upward and obliquely, thus causing considerable strain and exhaustion of the ocular muscles.

The usual infantile cases are *not amenable to treatment*, though the condition sometimes becomes less marked with advancing years; the correction of errors of refraction may be of some benefit. *Miner's nystagmus* generally disappears when the patient gives up this kind of work.

CHAPTER XXVI.

OCULAR THERAPEUTICS. GENERAL RULES FOR OPERATIONS UPON THE EYE.

THE eye being a very delicate and sensitive organ, it becomes necessary, in applying various therapeutic resources, to limit the strength of local applications and to observe care in the manner in which such remedies are applied.

Remedies employed in the treatment of diseases of the eye may be divided into 1. *constitutional*, and 2. *local*.

Constitutional Remedies are frequently prescribed and often exercise a marked influence on the progress of ocular disease. Many systemic disorders present ocular manifestations; and an important part of the treatment of the latter consists in general medication intended to correct the constitutional disturbance. Syphilis, tuberculosis, anæmia, and other disordered states give well-marked eye symptoms and diseases, which will yield only after proper *internal treatment*. Some ocular diseases are dependent upon a lowering of the general health, for which *tonics* are indicated. *Rest in bed* is often absolutely necessary for the effective control of some of the acute affections of the deeper structures of the eye. Thus it will be evident that the condition of the system cannot be disregarded in the treatment of ocular diseases.

LOCAL REMEDIES.

Drugs intended for local use to the eye are most frequently *dissolved in water;* a *saturated solution of boric acid* forms a very good *menstruum*. Such remedies are also used in *ointment*, *powder*, or *solid* form.

CLEANSING AND ANTISEPTIC SOLUTIONS.

Solutions of this sort are employed for *washing out the conjunctival sac and removing secretion.* They are used *freely*, are *bland and unirritating*, and should be *lukewarm* when employed. They may be allowed to run between the lids from an *eye-dropper*, using two or three dropperfuls, or poured out very conveniently by means of the *undine* (Fig. 238), or with a soft-rubber bulb syringe (Fig. 239).

FIG. 238.—Undine for Irrigating the Eye.

The cleansing and antiseptic solutions which are used most frequently are:

1. *Sterilized Water.*
2. *Boric Acid* in saturated solution (about 4 per cent.; half an ounce to the pint).
3. *Sodium Chloride* in physiological strength (0.6 per cent.; a teaspoonful to the pint).
4. *Mercuric Chloride*, from 1:10,000 to 1:6,000; a grain to the pint. This is also used for subconjunctival injections.
6. *Formalin*, 1:8,000, a grain to the pint.
7. *Potassium Permanganate*, 1:2,000, 4 grains to the pint.

Boric Acid is used more frequently than any other of these remedies. Though chemically an acid, it is *neutral, bland, and soothing.* It is often employed to irrigate the eye during *operations.* It is frequently prescribed with white vaseline, cold cream, or lanolin, in the form of

FIG. 239.—Soft-Rubber Eye Syringe.

an *ointment*, to prevent adhesion of the lids over night, when there is considerable discharge.

℞ Acidi borici, ... gr. iij.
Vaselini albi, ... ʒ ij.
M. ft. ungt.

It is sometimes dusted into the eye in cases of phlyctenulæ or ulcers of the cornea; when used for this purpose the powder must be in a state of *very fine* subdivision.

STIMULATING AND ASTRINGENT REMEDIES.

The remedies of this class used most frequently in connection with the eye are: Zinc Sulphate, Tannic Acid, Alum, Borax, Potassium Chlorate, Camphor, Silver Nitrate, Copper Sulphate, Yellow Oxide of Mercury, Ammoniated Mercury, and Calomel. They are intended to cure abnormal conditions of the conjunctiva, and are used principally in various forms of *conjunctivitis*. For this purpose they are prescribed in *small quantity*. Two or three drops are allowed to fall upon the everted lower lid from an eye-dropper; the latter must not be allowed to touch the lids, since this would lead to contamination of the liquid. Most of these remedies are used in *watery solution;* copper sulphate and alum are frequently employed in *crystals*.

Zinc Sulphate is used very largely in astringent collyria.

℞ Zinci sulph., ... gr. i.
Aquæ destill., ... ʒ i.
M. S. Two drops in each eye three times a day.

℞ Zinci sulph., ... gr. i.
Acidi borici, ... gr. v.
Aquæ destill., ... ʒ i.
M.

Tannic Acid is frequently used in combination with other astringents. It is often dissolved in glycerin, and

solutions of 5 to 25 per cent. are painted on the everted lids in trachoma.

℞ Acidi tannici, ... gr. ss.
Zinci sulph., ... gr. ss.
Aquæ destill., ... ʒ i.
M.

Alum (one-fourth to one grain to the ounce). Long-continued use is said to injure the cornea.

℞ Aluminis, ... gr. ss.
Aq. destill., ... ʒ i.
M.

A *crystal of alum*, in the form of a flattened pencil, is applied to the everted lids in *chronic conjunctivitis*, and in *mild* forms of *trachoma*.

Borax is used as a cleansing wash (ʒ i. to O i.), or in combination with other remedies:

℞ Zinci sulph., ... gr. ss.
Sodii biborat., ... gr. iij.
Aquæ destill., ... ʒ i.
M.

Potassium Chlorate is prescribed in solution, from 1 to 5 grains to the ounce.

Camphor.—Though feebly soluble in water, such solution (aqua camphoræ) is stimulating and astringent, and is often incorporated in collyria of this sort:

℞ Acidi tannici, ... gr. ¼.
Zinci sulph., ... gr. ss.
Aquæ camphoræ, ... ʒ ij.
Aquæ destill., ... ʒ vi.
M.

Silver Nitrate, dissolved in *distilled water*, may be used in the strength of gr. $\frac{1}{10}$ to gr. ½ to the ounce, *dropped into the conjunctival sac.* In *stronger solution* (1 to 5 grains to the ounce) it is *brushed upon the everted lids*, in chronic

conjunctivitis and in the papillary stage of purulent conjunctivitis. Solutions of nitrate of silver *spoil upon contact with organic matter.* The brush or cotton applicator should not be dipped into the bottle, but some of the solution should be poured into a small vessel for each use. Silver solutions *stain the conjunctiva* (*argyrosis*); hence they should be applied by the physician himself, and only for a *limited period.* When stronger than one per cent., they act as *disinfectants* and *caustics.*

Copper Sulphate ("bluestone") may be employed in solution (gr. ½ to ʒ i.); but its chief use is in the form of the *crystal.* A *flattened pencil* (Fig. 68) is rubbed across the everted lids (not omitting the posterior surface of the tarsus) in *trachoma,* and the *excess washed off* with water or solution of boric acid. The pencil should be flattened and have a blunt, rounded extremity.

Yellow Oxide of Mercury is insoluble in water; it is employed in the form of an *ointment* made with white vaseline, cold cream, vaseline cold cream, or lanolin. The ointment must be *thoroughly mixed,* and should be preserved in a glass jar which has been coated externally with asphalt varnish so as to be *impervious to light.* Its strength is usually one or two per cent.

℞ Hydrarg. oxidi flavi, ... gr. i.
Vaselini albi, ... ʒ ij.
M. ft. ungt.

℞ Hydrarg. oxidi flavi, ... gr. ij.
Ungt. aquæ rosæ, ... ʒ ij.
M. ft. ungt.

These ointments are frequently prescribed and are very useful in *blepharitis, chronic conjunctivitis, phlyctenular* keratitis and conjunctivitis, *interstitial keratitis,* and *opacities of the cornea.* In blepharitis the ointment is smeared along the margin of the lid; in the other affections, a small piece is transferred from the end of a glass rod or blunt in-

strument to the everted lower lid, and thus into the conjunctival sac.

Ammoniated Mercury is a white, insoluble powder prescribed in the same strength and under the same circumstances as the yellow oxide of mercury.

℞ Hydrarg. ammoniat., ... gr. i.
Vaseline cold cream, ... ʒ ij.
M. ft. ungt.

Calomel occurs in the form of a fine powder, which is dusted into the eye with a camel's-hair brush in cases of *phlyctenular keratitis* and corneal ulcers. This combination of mercury is thought to change slowly to corrosive sublimate as a result of contact with the tears.

Lead Acetate *should not be employed* in connection with the eye. It has the property of depositing an insoluble salt of lead upon any corneal abrasion; this *stain* cannot be removed. Lead and opium wash, so frequently used in other parts of the body, is not, therefore, a desirable application for the eye.

DISINFECTANTS.

True disinfectants (capable of destroying germs) cannot be instilled into the conjunctival sac under ordinary circumstances, since they would injure the cornea. They are, however, applied to *circumscribed areas*, the excess being washed off by some bland solution. *Corneal ulcers*, especially when *indolent or infected*, and *purulent conjunctivitis*, furnish common indications for such use. Some of the remedies classified under this head, though not, strictly speaking, true disinfectants in the strengths in which they are employed, have an inhibitory action upon the growth and development of micro-organisms and thus act as *practical disinfectants*. The disinfectants used most commonly in connection with the eye are: Mercuric Chloride, Alco-

hol, Chlorine Water, Carbolic Acid, Formalin, Tincture of Iodine, Silver Nitrate, Protargol, Iodoform, and the Cautery.

Mercuric Chloride (Corrosive Sublimate) is prescribed very frequently in *purulent conjunctivitis.* It may safely be used in the strength of 1:5,000; when stronger, it acts unfavorably upon the cornea, and must consequently be limited in its application to the *everted lids,* and the excess carefully washed off. A strong solution, 1:500, is often rubbed into the conjunctiva after this membrane has been freed from trachoma follicles by the operation of expression. Solutions of corrosive sublimate attack the metal of instruments and dull the cutting edges.

Alcohol is a very efficient disinfectant of the blades of eye instruments.

Chlorine Water diluted with 10 to 20 parts of water is sometimes employed in *purulent conjunctivitis.* It must be *freshly prepared.*

Carbolic Acid (three-per-cent. solution) is used only for disinfecting instruments. Stronger solutions and pure carbolic acid are sometimes applied to *infected ulcers of the cornea.*

Formalin.—Solutions of 1:1,000 and 1:2,000 are used in purulent conjunctivitis; solutions of 1:500 are applied to infected ulcers; solutions of 1:200, and formalin vapor, are sometimes employed for the disinfection of instruments.

Tincture of Iodine is an excellent remedy in the treatment of *infected ulcers.* It is applied upon a small piece of cotton rolled upon the end of an applicator, and the excess washed off with water (p. 121).

Silver Nitrate is a very efficient and popular disinfectant. In one- or two-per-cent. solution it is applied to the everted lids in purulent and in other forms of *conjunctivitis,* and the excess neutralized by a solution of sodium chloride. In two-per-cent. solution, one drop is instilled

into the eyes of the new-born as a prophylactic measure against ophthalmia neonatorum. In stronger solution, and in solid stick, it is applied to *infected and indolent ulcers*, the excess being neutralized by salt solution. It is fused with potassium nitrate in various proportions, constituting the "*mitigated stick.*" For the purpose of producing anæsthesia preliminary to silver applications, solutions of *nitrate of cocaine* should be used instead of the customary hydrochlorate, since the latter alkaloidal salt is incompatible and precipitates chloride of silver, which leaves a permanent stain upon the cornea.

Iodoform is a *feeble* disinfectant which is occasionally dusted upon corneal ulcers, or used in two- to four-per-cent. ointment in such lesions. It is not infrequently dusted upon wounds after plastic operations.

Protargol is an *organic salt of silver*, soluble in water, forming a brown solution It is used in one- to five-per-cent. solutions in the same class of cases in which silver nitrate is indicated. It is a decided *germicide*, and lacks the irritating qualities of silver nitrate.

The Cautery gives us the most certain means of limiting the spread of *corneal ulcers*, by destroying the infecting micro-organisms. It is also used in conical cornea, and in epithelioma of the lid.

MYDRIATICS AND CYCLOPLEGICS.

Mydriatics are remedies which produce *dilatation of the pupil. Cycloplegics* are agents which cause *paralysis of the ciliary muscle* (paralysis of accommodation). Practically, these two terms are *interchangeable*, since, with two exceptions, the remedies used as mydriatics also produce paralysis of the ciliary muscle.

The drugs which are commonly employed to induce mydriasis and cycloplegia are *atropine* and *homatropine;* very

much less frequently we use duboisine, daturine, hyoscyamine, and scopolamine.

The remedies employed to produce dilatation of the pupil, without practical action on the ciliary muscle, are *cocaine and euphthalmin.*

Indications.—Agents of this class are used (1) in *iritis*, for dilating the pupil, preventing adhesions, and exerting a sedative action; (2) in various diseases of the *cornea* and of the *deeper structures of the eye;* (3) in *central ulcer of the cornea;* (4) after certain *operations;* (5) to paralyze accommodation in *estimating the refraction;* (6) to dilate the pupil for *ophthalmoscopic* examination; and (7) to enlarge the pupil in lamellar and nuclear *cataract.*

Atropine, the alkaloid of *Belladonna,* is the most commonly employed mydriatic; it is prescribed in the form of *sulphate.* The strength of solution varies from *one-half to two per cent.;* a one-per-cent. solution is used most frequently.

℞ Atropin. sulphat., ... gr. i.
Aquæ destill., ... ʒ ij.
M. S. *Poison.* One drop in each eye every four hours.

Atropine *paralyzes the sphincter of the pupil and stimulates the dilator.* After the instillation of two or three drops at intervals of ten minutes, pronounced action will have taken place in half an hour after the last dose; *the effects last for a week or ten days.* Atropine and other mydriatics (except cocaine and generally euphthalmin) *increase intraocular tension.* They are *contraindicated in glaucoma,* and in persons who have a tendency to this disease; we should carefully test the tension in persons past middle life before instilling atropine.

Atropine Poisoning.—In *susceptible* individuals atropine may cause *general toxic symptoms:* Dryness of the throat,

flushing of the face, headache, vomiting, quick pulse, cutaneous eruption, excitability, and even delirium. *The antidote is morphine.* In persons who show such an idiosyncrasy, or in others in whom we wish to push the remedy, it is well to instruct the patient to *press the finger against the lachrymal sac* for several minutes after each instillation. When the susceptibility is very great, one of the *other mydriatics* may be resorted to, or we may use a ten-per-cent. solution of *aqueous extract of belladonna* in water; *ophthalmic discs*, which contain very small doses, may prove useful in these cases.

Atropine Irritation. — In some persons atropine may cause considerable *local irritation*, showing itself in congestion, œdema of the lids, eczematous condition about the lids, and conjunctival (follicular) catarrh.

In using atropine or other solutions (myotics and anæsthetics), for the local effect upon the cornea or deeper portions of the eye, the drop is allowed to *fall upon the cornea*, the upper lid being raised, and the patient directed to throw the head back and to look down.

Duboisine Sulphate (gr. $\frac{1}{2}$ to ʒ ij.), Daturine Sulphate (gr. $\frac{1}{4}$ to ʒ ij.), Hyoscyamine Hydrobromate (gr. $\frac{1}{2}$ to ʒ ij.), and Scopolamine Hydrobromate (gr. $\frac{1}{8}$ to ʒ ij.) are occasionally used as *substitutes for atropine.* They have similar attributes, are contraindicated in increased tension, and may also produce systemic poisoning.

Homatropine Hydrobromate resembles atropine in its actions, but is *milder.* It is very largely used to *paralyze accommodation* during the examination for *errors of refraction.* Though this effect is not so perfect as with atropine, it is *sufficient for all practical purposes, and lasts only 24 or 36 hours,* thus exposing the patient to very much less inconvenience. For refraction cases, it is usually used in two-per-cent. solution, one drop being instilled every five or ten minutes, for three or four doses; *half an hour* after the final dose, the eye is ready for ex-

amination. It is frequently combined with cocaine for this purpose:

℞ Cocain. hydrochlor., ... gr. i.
Homatropin. hydrobrom., ... gr. ij.
Aquæ destill., ... ʒ ij.
M.

Euphthalmin is a new mydriatic which has proved to be very useful for the purpose of dilating the pupil for *ophthalmoscopic examination.* The hydrochlorate is used in five- or ten-per-cent. solution; one or two drops cause mydriasis in thirty minutes, and the effects pass off in two or three hours. It has but a feeble action upon accommodation, and rarely causes increase in tension.

Cocaine Hydrochlorate is frequently used to produce *moderate dilatation* of the pupil for *ophthalmoscopic examination.* One or two drops of a four-per-cent. solution cause sufficient dilatation in twenty minutes, produce *insignificant interference with accommodation,* and the effects disappear within an hour. Cocaine acts by constricting the blood-vessels of the iris. *It diminishes intraocular tension.* It is sometimes *combined* with other mydriatics, and then *increases* the action of the associated remedy.

℞ Atropin. sulphat., ... gr. i.
Cocain. hydrochlor., ... gr. ij.
Aquæ destill., ... ʒ ij.
M. S. *Poison.*

MYOTICS.

Myotics *diminish the size of the pupil.* They produce tonic *contraction of the sphincter and of the ciliary muscle,* and *diminish intraocular tension.* These agents are employed chiefly in *glaucoma;* sometimes in ulcers of the cornea, especially when peripheral. *Eserine* ($\frac{1}{8}$ to $\frac{1}{2}$ per cent.) and *pilocarpine* ($\frac{1}{2}$ to 1 per cent.) are prescribed for these purposes. *Eserine is stronger,* and sometimes has

a tendency to produce conjunctival irritation and iritis, and occasionally constitutional symptoms. *Pilocarpine is milder* and free from these drawbacks; it is sometimes given hypodermically to cause diaphoresis in certain diseases of the eye.

℞ Eserin. salicylat., ... gr. ½–½
Aquæ destill., ... ʒ ij.
M. S. *Poison.*

℞ Pilocarpin. nitrat., ... gr. ss.–i.
Aquæ destill., ... ʒ ij.
M. S. *Poison.*

LOCAL ANÆSTHETICS.

Cocaine Hydrochlorate is the most commonly employed remedy for producing local anæsthesia of the conjunctiva, cornea, and to a certain extent the iris, during *operations* upon the eye. It may be used *subcutaneously* for operations upon the lid, due regard being exercised for its *poisonous qualities.* The *strength* of solution is usually two to four per cent. It is also of service as a *temporary anodyne* in corneal and iritic affections, and very useful as a mydriatic for *ophthalmoscopic examinations.* Its property of *lowering the intraocular tension* is sometimes a valuable feature. It is frequently combined with atropine and homatropine, and sometimes with other remedies. Cocaine has a tendency to cause *desiccation of the cornea* and sometimes *superficial ulceration;* hence after the instillation of this remedy, the patient should be directed to keep the *lids closed.* One drop of a four-per-cent. solution, and a second after a few minutes, is sufficient to anæsthetize the cornea for the removal of foreign bodies; for more penetrating effects, the instillations are repeated three or four times, at intervals of two or three minutes. Solutions of cocaine *do not keep well,* and should be *freshly prepared* previous to use in operations.

Holocain Hydrochlorate is a local anæsthetic of recent introduction, which has become *very popular* and has already *supplanted cocaine among many oculists.* It is usually employed in one-per-cent. solution. The *advantages* of this new remedy as compared with cocaine are: it acts more *quickly,* is more *penetrating,* does *not dilate the pupil,* is *not poisonous when applied locally,* and its *solution does not spoil. It cannot be used hypodermically,* since it causes toxic symptoms when employed in this way.

Eucain "B" is another local anæsthetic which was introduced as a substitute for cocaine. Its chief advantages are that it does not dilate the pupil and is *less poisonous;* hence it is safer to use by the *hypodermic method.* But it causes some conjunctival irritation, and does not seem so uniform in its action as cocaine. It is employed hypodermically, but not often for instillation. It is used in five-per-cent. solution.

OTHER THERAPEUTIC MEASURES.

Heat.—*Hot compresses* are prescribed in *affections of the cornea, iris, and ciliary body.* They are applied by means of flannel or absorbent cotton wrung out of water which is as hot as can be borne (115°); they are placed upon the *closed lids,* and *renewed every minute or two.*

Cold.—*Cold compresses* are used in *inflammatory affections of the lids.* The best method of applying them is as follows: Strips of lint, lintine, or similar material are folded so as to make *pads* of four thicknesses, about 1½ inches square; a number of these are moistened and *laid upon a block of ice;* from the ice they are transferred to the *closed eyelids,* and *changed* as soon as they become warm. In the absence of ice, the compresses may be wrung out of *cold water. Ice* should never be applied directly to the lids.

Electricity is not used frequently in ocular therapeutics,

except in the form of the *electro-cautery*. *Electrolysis* may be employed for the removal of distorted lashes. *The Galvanic and Faradic currents* are occasionally resorted to in paralyses of ocular muscles and other chronic affections.

Local Blood-letting is of great benefit in affections of the *deeper structures of the eye*, especially in *iritis*. *Leeches* are very frequently prescribed; from two to four are applied to the temple, midway between the outer canthus and the tragus. *The artificial leech* of Heurteloupe is often used in this situation, and an ounce of blood abstracted.

Massage is sometimes prescribed in *interstitial keratitis* and in *corneal opacities*. A small quantity of some form of ointment is placed in the conjunctival sac; then the finger is applied to the closed upper lid, and the cornea massaged gently for a few minutes at a time.

Protective Measures of various sorts are applied to the eye *to insure rest, to keep out light*, air, wind, and dust, and *to give support*. The patient is often kept in a *dark or shaded room* during the course of diseases of the retina and other deep structures. Various kinds of *smoked glasses*, of different tints, are prescribed: plane, curved (coquilles), and goggles. Mica glasses may be worn by stone-cutters. *Patches and shades* of green and black are made use of when imperfect protection is sufficient. The application of *eye bandages* is described on p. 392 (Figs. 242 and 243).

GENERAL CONSIDERATIONS OF OPERATIONS.

The strict rules of *asepsis and antisepsis* which govern modern general surgery are also indicated in ophthalmic operations, except that *strong solutions of germicides are not tolerated* by the eye. In other respects, the preparations connected with an operation are similar to those employed by the general surgeon.

Preparation of the Patient.—When operated upon in a hospital, the patient should become accustomed to his

surroundings for twenty-four hours previous to operation. He should receive a *bath* and then take a mild *cathartic* the night before, followed by an *enema* on the morning of the operation. He should be in *good physical condition;* old age, albuminuria, and diabetes are no contraindications, but such patients often require special care.

It is imperative to examine the conjunctiva and the lachrymal sac before deciding to operate, especially if the operation be an important one upon the eyeball, such as iridectomy or cataract extraction. The presence of *purulent or muco-purulent secretion* from the conjunctiva or lachrymal

FIG. 240.—Drum Used to Test the Cutting-Edges of Eye Instruments.

sac renders an operation upon the eyeball extremely hazardous, on account of the *danger of infection.* In such cases, the conjunctival or lachrymal affection must first be cured by appropriate treatment. In cases of doubt, it is well to bandage the eye for twenty-four hours, and then to examine the dressing.

Preparation of the Hands of the Operator.—The hands should be *scrubbed* thoroughly with soap and warm water, and then immersed for a minute in 1:1,000 *corrosive sublimate* solution.

Preparation of Instruments.—*Blunt instruments* should be *cleaned* and *polished, boiled* in one-per-cent. solution of soda, *rinsed* with sterile water, and then kept in a *sterile solution* of salt (0.6 per cent.), or boric acid (4 per cent.),

or dried and wrapped in *sterilized gauze*. *Sharp instruments* should be *cleaned* carefully, dipped into *boiling water*, transferred to *alcohol*, and finally to *sterile solution* of salt (0.6 per cent.), or boric acid (4 per cent.), or else *dried* and covered with *sterilized gauze*. Previous to use, the cutting qualities are tested upon thin kid stretched in the testing-drum (Fig. 240).

FIG. 241.—Knapp's Operating-Chair.

Position of the Patient.—The patient may be operated upon either in bed, or on a table, or seated upon a special operating-chair (Fig. 241). The *light*, whether daylight or artificial illumination, must be good, and the field of operation must be well illuminated; for the latter purpose a *strong reading-glass* is often used to throw the light upon the eye during operations upon the lens or iris.

Preparation of the Region of Operation.—The eyelids, including the lashes and the surrounding skin, should be *washed* with soap and warm water, and then with *corrosive sublimate* solution (1:5,000). The *everted lids* are *cleansed* gently with solution of mercuric chloride, 1:5,000, or boric acid, 4 per cent., applied by means of absorbent cotton.

Anæsthesia.—In the great majority of adult cases, local anæsthesia is sufficient. Two drops of a two- or four-per-cent. solution of hydrochlorate of *cocaine*, or of a one-per-cent. solution of *holocain* hydrochlorate, are instilled every few minutes for three or four doses, the lids being kept closed in the intervals. Cocaine solutions must be freshly prepared, since they do not keep well.

In children and in nervous adults, also in enucleations, in glaucoma with very high tension, in blepharoplastic operations, and occasionally in other procedures, a *general anæsthetic* is necessary.

In operations upon the lid a one- or two-per-cent. solution of cocaine or of eucain B may be used *hypodermically.* A safer plan is to use the *local infiltration method advocated by Schleich.* General anæsthesia is often necessary in lid operations.

Cleansing Solutions.—In the course of operations upon the eyeball, it is necessary to *cleanse the seat of operation and irrigate the cornea* frequently, to prevent desiccation. The solutions used for this purpose are *boric acid,* 4 per cent., *salt,* 0.6 per cent., and *mercuric chloride,* 1:10,000. These cleansing solutions are applied either by means of an undine (Fig. 238), a pipette or eye-dropper, or small wads of absorbent cotton known as "*cotton sponges.*"

Dressings vary with the nature of the operation. *Sterilized gauze and absorbent cotton,* used *dry or soaked* in antiseptic solutions (mercuric chloride, 1:5,000, or boric acid, 4 per cent.) are generally applied next to the closed eye-lids, covered by an additional layer of dry cotton, and retained by a *bandage* covering one or both eyes, sometimes by strips of *isinglass plaster.*

FIG. 242.—Monocular Bandage.

Eye bandages are 1½ inches wide, 5 or 7 yards long, and made of *gauze, muslin,* or *flannel.* If used for *protection* only, they are applied *lightly;* if for *pressure,* they are put on *tightly;* in the latter case, care must be taken that the depression existing between supraorbital margin and nose, in which the eye is placed, is properly filled out.

The Monocular Bandage (Fig. 242) is applied as follows: Begin over the temple of the same side as the affected eye (the right, for example); make one turn around the forehead, then pass across the occiput, below the right ear, and obliquely across the right eye; then another turn about the forehead, below the right ear, across the right eye, alternating in this way three or four times.

FIG. 243.—The Binocular Bandage.

The Binocular Bandage (Fig. 243).—Begin over the temple of one side—the right, for example; make a full turn around the forehead and continue to the left temple, then obliquely across the occiput, below the right ear, across the right eye; around the upper occipital region, above the right ear, downward over the left eye, below left ear, across the occiput; below the right ear, across the right eye, and alternate in this manner for three or four turns.

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